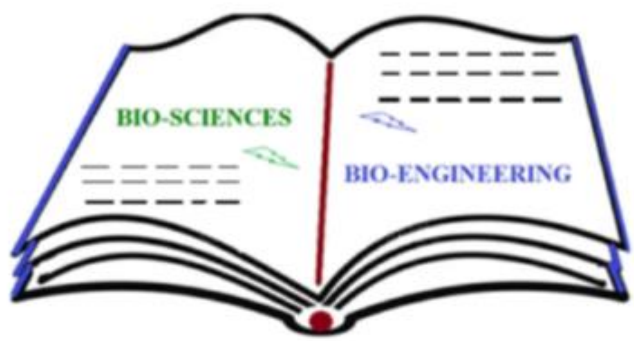
B.Tech Curriculum
Biosciences & Bioengineering



INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI

EDITORS

VIBIN RAMAKRISHNAN & KANNAN PAKSHIRAJAN

GROUP COORDINATORS

(In alphabetical order)

CHAUDHARY, NITIN

KUMAR, MANISH

MANDAL, BIMAN B.

NAGOTU, SIRISHA

SIVAPRAKASAM, SENTHILKUMAR

TAMULI, RANJAN

PREFACE

Curriculum development is an integral part of any educational programme. The present revised BTech Biotechnology curriculum is aimed at bringing about qualitative improvement in the undergraduate programme offered by Biosciences and Bioengineering Department of IIT Guwahati. It includes appropriate levels of courses in basic and applied sciences, mathematics, computer, engineering sciences and courses relevant to the present day environment of changing technologies in the field of biological sciences and bioengineering. The Department initiated revision in its BTech curriculum in order to catch up with the technological developments taking place in relevant industries and research organizations. A series of meetings were held at both the Department and the Institute levels over the recent 3-4 years for revising the BTech Biotechnology curriculum. All the department specific courses in this revised curriculum have been formulated based on feedback from renowned experts in the field, who represented research and development organizations, industry and the academia, including those from Indian Institutes of Technology and other world-class Universities.

While formulating the department specific courses and their detailed contents in this revised curriculum, the following important elements have been kept in mind: i) major opportunities of graduates in Biotechnology (ii) competency profile of BTech Biotechnology students with a view to meet the changing needs of technological developments and requirements of the employer iii) mobility of BTech Biotechnology students for their professional growth.

The revised B.Tech Biotechnology curriculum aims at developing desired professional, managerial and communication skills, essential for graduates in Biotechnology to meet their requirements. We hope that the revised curriculum will prove useful to students, who aspire to do academic research in world-class universities or serve as process engineers and R&D scientists in leading biotechnology industries.

Dr. Kannan Pakshirajan
Professor and Former Head
Department of Biosciences and Bioengineering, IIT Guwahati

Curriculum Revision:

Purpose, Process, Partnership and Prospects

Global market of healthcare products has crossed 1.1 trillion US Dollars in 2016, with America and Europe registering 70 % of total sales. The number of biotechnology-derived therapeutic solutions is also progressing steadily in last two decades. Biotechnology is a multidisciplinary subject, which innocuously combines multiple fields of science and engineering. This rapidly advancing field, therefore, demands good number of trained people. The priority areas of operation and business of biotechnology has been continuously changing over last two decades. Support of trained workforce with knowledge in recent developments, is the key for the sustainable development of this sector.

Curriculum Revision at IITG, has been initiated in 2014-15, followed by a series of preliminary discussions on this topic at the institute and the departmental level, mostly under the patronage of Academic office. Key developments in last couple of years may be summarized as follows:

1. After a series of discussions, we have formed a faculty sub-committee for revision. We undertook a 'kind of principal component analysis' of the course titles from Biosciences/Bioengineering related disciplines, in top 25 universities worldwide, based on Times ranking.

2. Based on this analysis, we have identified the titles for core and elective courses. We thought that, this exercise would help us to stay current as per global standards.

3. We have finalized the titles in a faculty meeting for core and elective courses, and close to about 25 faculty members of the department submitted syllabus as per the designed titles, by May 2017.

4. We wrote to approximately 50 faculty members and distinguished scientists all over the country to evaluate the syllabus in their respective areas of expertise. We have received positive reply from about two dozen experts from premier institutions, and about a dozen reviews were received before the last date, in July 2017. List of reviewers is attached.

5. The syllabus and external reviews were again circulated to all faculty members for feedback.

6. We formed six groups (A to F) with faculty coordinators appointed to consult and conduct group discussions with the respective authors and other interested faculty members. These sub groups debated on the syllabus content along with external reviewer comments and made recommendations to the faculty council.

7. Faculty meetings held on March 2018 have finalized the syllabus after making further final modifications on the sub group recommendations.

8. The complete document has been submitted to the Senate for their recommendations and approval.

The successful completion of this exercise was due to the vision and perseverance of Director, IIT G, well supported by Dean (Academic), in undertaking this laborious task of restructuring the curriculum at the institute level. About 25 faculty members of the Department of Biosciences and Bioengineering, contributed in the design and further development of this newly proposed curriculum. We are especially thankful to Dr. Senthilkumar, who supported us beyond words, in finalizing the courses related to Biochemical engineering. Few senior faculty members who have discussed few points with group coordinators and convener, also contributed to the success of this important task.

We thank the time and expertise of external reviewer's in sincerely participating in this exercise with great enthusiasm. We appreciate their commitment towards science, academics, and above all, future of a new generation of students. We also take this opportunity to acknowledge Mr. Raghuveer Yadav and Chandan Nath of BSBE, for their support in formatting the script.

Considering its importance as a principal driving force for global economy, and its direct proximity to the overall well-being of a population, governments in developed and developing economies are investing in this sector much more than ever before. Production, dissemination and practice of biotechnology related information, and management of its knowledge base can be supported by a well-trained workforce, which can further catalyze growth of this industry. As a country, our success in making suitable policy changes, that helped us growing as a global IT hub, may be suitably adapted to healthcare as well. We wish to see more biotech and pharmaceutical companies coming up, creating a sustainable environment for developing more effective and affordable solutions, such that weaker sections of the society will also benefit from new technological solutions.

Dr. Vibin Ramakrishnan
Professor
Secretary, Department Undergraduate Programme Committee
Department of Biosciences & Bioengineering, IIT Guwahati

B. Tech Biosciences & Bioengineering

Semester	Course Title	L	T	P	C
1	MA 101 Mathematics-I	3	1	0	8
1	CH 101 Chemistry	3	1	0	8
1	PH 101 Physics-I	2	1	0	6
1	EE 101 Basic Electronics	3	1	0	8
1	CH 110 Chemistry Lab	0	0	3	3
1	PH 110 Physics Lab/ME110 Workshop-1	0	0	3	3
1	CE 101 Engineering Drawing*	2	0	3	7
				Total Credits	**43**

1	HS 101 English Communication	2	0	2	0

2	MA 102 Mathematics-II	3	1	0	8
2	BT 101 Introductory Biology	3	0	0	6
2	PH 102 Physics-II	2	1	0	6
2	CS 101 Introduction to Computing	3	0	0	6
2	ME 101 Engineering Mechanics	3	1	0	8
2	CS 110 Computing Lab	0	0	3	3
2	EE 102 Basic Electronics Laboratory	0	0	3	3
2	ME110 Workshop-1/ PH110 Physics Lab	0	0	3	3
				Total Credits	**43**

2	SA 1xx Students Activity Course -I	0	0	2	0

3	MA 201 Mathematics-III	3	1	0	8
3	BT 201 Biochemical Process Calculations	2	1	0	6
3	BT 202 Bio-thermodynamics	2	1	0	6
3	BT 203 Biochemistry	3	0	0	6
3	BT 204 Genetics	3	0	0	6
3	BT 205 Cell and Molecular Biology	3	0	0	6
				Total Credits	**38**

3	SA 2xx Students Activity Course -II	0	0	2	0
3	Minor Course -I	3	0	0	6

4	BT 206 Microbiology	3	0	0	6
4	BT 207 Genetic Engineering	3	0	0	6
4	BT 208 Transport Phenomenon in Bioprocesses	3	1	0	8
4	BT 209 Bio-reaction Engineering	2	1	0	6
4	HS 1xx HSS Elective-I Level-I	3	0	0	6
4	BT 211 Basic Biotechnology Laboratory	0	0	6	6
				Total Credits	**43**

4	SA 3xx Students Activity Course -III	0	0	2	0
4	Minor Course -II	3	0	0	6

Semester	Course Title	L	T	P	C
5	BT 301 Biophysics	2	1	0	6
5	BT 302 Bioinformatics	2	0	2	6
5	BT 303 Biochemical Engineering	2	1	0	6
5	BT 304 Immunology	3	0	0	6
5	BT 311 Biochemical Engineering Laboratory	0	0	6	6
5	BT 312 Analytical Biotechnology Laboratory	0	0	6	6
5	HS 1xx HSS Elective-II Level-I	3	0	0	6
				Total Credits	**42**
5	SA 4xx Students Activity Course -IV	0	0	2	0
5	Minor Course -III	3	0	0	6
6	BT 305 Computational Biology	2	0	2	6
6	BT 306 Bio-separation Engineering	3	0	2	8
6	BT 307 Biological Data Analysis	2	0	2	6
6	BT 308 Bioengineering	3	0	0	6
6	OE xxx Open Elective	3	0	0	6
6	BT xxx Departmental Elective - 1	3	0	0	6
6					
				Total Credits (approx.)	**38**
6	Minor Course – IV	3	0	0	6
7	BT Xxx Departmental Elective -II	3	0	0	6
7	BT Xxx Departmental Elective –III	3	0	0	6
7	OE xxx Open Elective	3	0	0	6
7	OE xxx Open Elective	3	0	0	6
7	BT 401 B.Tech Project – 1	0	0	6	6
7	HS 2xx HSS Elective – III Level - II	3	0	0	6
				Total Credits (approx.)	**36**
7	Minor Course – V	3	0	0	6
8	BT Xxx Departmental Elective –IV	3	0	0	6
8	BT Xxx Departmental Elective –V	3	0	0	6
8	BT Xxx Departmental Elective –VI	3	0	0	6
8	OE xxx Open Elective	3	0	0	6
8	BT 402 B.Tech Project – II	0	0	6	6
8	HS 2xx HSS Elective – IV Level - II	3	0	0	6
				Total Credits (approx.)	**36**

Electives

Semester	Component	Course Title	L	T	P	C
7 & 8	Departmental Elective	BT 403 Human Biology and Diseases	3	0	0	6
7 & 8	Departmental Elective	BT 404 Plant Biotechnology	3	0	0	6
7 & 8	Departmental Elective	BT 405 Cancer Biology and Therapeutics	3	0	0	6
7 & 8	Departmental Elective	BT 406 Stem Cell Biology and Engineering	3	0	0	6
7 & 8	Departmental Elective	BT 407 General Virology	3	0	0	6
7 & 8	Departmental Elective	BT 408 Structural Biology	3	0	0	6
7 & 8	Departmental Elective	BT 409 Cell Signaling & Development	3	0	0	6
7 & 8	Departmental Elective	BT 410 Proteomics: Methods & Applications	3	0	0	6
7 & 8	Departmental Elective	BT 411 Metagenomics	3	0	0	6
7 & 8	Departmental Elective	BT 412 Enzymology	3	0	0	6
7 & 8	Departmental Elective	BT 413 Metabolic Engineering	3	0	0	6
7 & 8	Departmental Elective	BT 414 Nano-biotechnology	3	0	0	6
7 & 8	Departmental Elective	BT 415 Tissue Engineering & Regenerative medicine	3	0	0	6
7 & 8	Departmental Elective	BT 416 Bioenvironmental Engineering	3	0	0	6
7 & 8	Departmental Elective	BT 417 Bioprocess Instrumentation & Control	3	0	0	6
7 & 8	Departmental Elective	BT 418 Systems Biology	3	0	0	6
7 & 8	Departmental Elective	BT 420 Drug design and discovery	3	0	0	6
7 & 8	Departmental Elective	BT 421 Neurobiology	3	0	0	6

Departmental Electives (Science): BT 403 – BT 412 (total 10)

Departmental Electives (Engineering): BT 413 – BT 418 (total 6)

Open Electives from Department: BT 420 – BT 421

Total Mandatory Credits: 314

Open Electives (OE): 4

Departmental Electives: 4

HSS Electives: 4

Core Courses	Faculty Coordinator
Introductory Biology	Manish Kumar
Biochemical Process Calculations	Senthil Kumar S
Biochemistry	Vikash Kumar Dubey
Microbiology	Sirisha Nagotu
Genetics	Rakhi Chaturvedi
Basic Biotechnology laboratory	Gurvinder K Saini
Transport Phenomenon in Bioprocesses	Senthilkumar S/Debasish Das
Bioreaction Engineering	Soumen K Maiti
Cell and Molecular Biology	Kusum K. Singh
Genetic Engineering	Bithiah G Jaganathan
Bioinformatics (Theory + Lab)	B Anand
Analytical Biotechnology Laboratory	Vishal Trivedi
Biochemical Engineering	Debasish Das
Biochemical Engineering Laboratory	Debasish Das
Biophysics	Nitin Chaudhary
Computational Biology (Theory + Lab)	Vibin Ramakrishnan
Immunology	Sachin Kumar
Bioseparation Engineering (Theory + Lab)	Aiyagari Ramesh
Bioengineering	Biman B Mandal
Biological Data Analysis (Theory + Lab)	Biplab Bose
Biothermodynamics	Senthilkumar S

Electives

Human Biology and Diseases	Piruthvi Sukumar
Metabolic Engineering	Senthilkumar S & Debasish Das
Plant Biotechnology	Rakhi Chaturvedi
Systems Biology	Biplab Bose
Bioenvironmental Engineering	K Pakshirajan
Cancer Biology and Therapeutics	Anil M Limaye
Bioprocess Instrumentation & Control	Senthil Kumar
Drug Design and Discovery	Vikas Kumar Dubey
Stem Cell Biology & Engineering	Rajkumar P. Thummer
General Virology	Sachin Kumar
Nanobiotechnology	Pranjal Chandra
Neurobiology	C. Navin Gupta
Structural Biology	Shankar P Kanaujia
Physical Biology	B Anand
Cell Signaling & Development	Ranjan Tamuli
Proteomics: Methods & Applications	Vishal Trivedi
Metagenomics	Sanjukta Patra
Tissue Engg. & Regenerative Medicine	Biman B Mandal
Enzymology	Vikash Kumar Dubey

REVIEWERS

PROFESSOR L S SHASHIDHARA
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PROFESSOR SAMUDRALA GOURINATH
JAWAHARLAL NEHRU UNIVERSITY, NEW DELHI

BT 101

Introductory Biology

L T P C

3 0 0 6

Semester 2, JAN- MAY

Lectures: 40-42

Description/Preamble

The course is designed to get students acquaintance with the basic biological principles, and develop new engineering solutions for medicine, industry, environment, and many other fields inspired from the field of biology. The syllabus covered, unifies the life sciences with engineering and the physical sciences. Modern biology will help the engineering students to explore and understand the way living cells, tissues, organs and diverse organisms build, control, synthesize, process, and adapt to the environment during the long evolutionary period. Basic knowledge of biology will help to develop new technologies inspired by the stably adapted system (biological resources) existing in the nature and translate them into products that meet real world challenges.

Objective

To empower the engineering students with the basic knowledge of biological sciences and its applications. Inspired from the field of biology, engineering student should be able to translate their theoretical and practical knowledge gained during enrollment in various subjects.

Pre-requisites

This course is designed for undergraduates having reasonably less biology background or those who did not study biology in secondary school.

Syllabus

Evolution of life: Origin of Life; Darwin's concepts of evolution; Biodiversity.
Cell, the structural and functional unit of life: Three domains of life; cell types, cell organelles and structure; Basic biomolecules of cell.
Nutrients, bioenergetics and cell metabolism: Essential nutrients to sustain life; biological energy and laws of thermodynamics, basics of aerobic and anaerobic glycolysis and citric acid cycle.
Genes and chromosomes: DNA, DNA replication; Central dogma of molecular biology: Transcription and translation; Mendelian Genetics; Genetic engineering/Cloning and its applications.
Biological systems: Body systems required to sustain human physiology, special sense organs including hearing, taste, smell and visual receptors.

Text Books

1. J. L. Tymoczko, J. M. Berg and L. Stryer, Biochemistry, 8th Ed, W. H. Freeman & Co, 2015.

2. D. L. Nelson and M. M. Cox, Lehninger Principles of Biochemistry, 7th Ed, Macmillan Worth, 2017.

References

1.N. Hopkins, J. W. Roberts, J. A. Steitz, J. Watson and A. M. Weiner, Molecular Biology of the Gene, 7th Ed, Benjamin Cummings, 1987.

2. C. R. Cantor and P. R. Schimmel, Biophysical Chemistry (Parts I, II and III), W.H. Freeman & Co., 1980.

3. C. C. Chatterjee, Human Physiology, Vol 1 & 2, 11th Ed, Medical Allied Agency, 1987.

4. Hall, B.K., Evolution: Principles and Processes, 1st Ed, Jones & Bartlett, 2011.

Evaluation & Grading

Evaluation will be based on marks scored during written exam in the two quizzes, mid semester and end semester examinations. Grading from AS to DD and F, as per standard grading system followed by institute.

BT 201

Biochemical Process Calculations

L T P C

2 1 0 6

Semester 3, JUL-NOV

Lectures: 28, Tutorials: 14

Description/Preamble

The primary aim of this course is to train the students in the fundamental principles of material and energy balances encountered in biochemical engineering processes. The ultimate benefit of 'Biotechnology' is realized during up-scaling the lab-scale biological processes in to industrial scale, which involves unit operations and unit processes. This proposed course focus on solving material/energy balances for selected unit operations and unit processes available in a biotech industry. The chapters are organized such a way to provide the basic understanding of units & conversions, basic calculations, basic principles of material/energy balances, solving material/energy balances for steady and un-steady state systems and a brief introduction to microbial stoichiometry & its application.

Objective

Establish mathematical methodologies for the computation of material balances and energy balances in biochemical engineering. Present an overview of industrial biochemical processes. Develop a fundamental understanding of the basic principles of biochemical engineering processes and calculations. Examine and select pertinent data, and solve material and energy balance problems. Give examples of important application of material balances in biochemical engineering processes. Solving stoichiometric balances governing a biochemical reaction and its application.

Pre-requisites

Not required

Syllabus

Dimensions and Units: Dimensions and System of Units, Fundamental and derived units, Dimensional consistency, Dimensional equations, Different ways of expression of units of quantities and physical constant, Unit conversion and significance.

Basic Biochemical Calculations: Mole, molecular weight, mole/mass fractions calculations, composition of gas, liquid and solid mixtures, Ideal gas law and other equations of state equations & applications, Dalton's law, Raoult's law, Henry's law, Solutions and properties.

Material Balances without biochemical reaction: Process flow sheet, degree of freedom, Material balance with and without recycle; Bypass and purge streams, Material balances around equipments related to unit operations like filtration, extraction, distillation column, adsorption and drying/freeze drying. Material balance of unsteady state operations

Material balance involving biochemical reaction: Concept of limiting and excess reactants, percentage conversion, yield and selectivity. Single and multiple reaction Lumped and Distributed processes, Material balance involving reactions with reference to penicillin, lactic acid, and ethanol and biopharmaceuticals production.

Energy Balance: Law of thermodynamics, heat capacity of gas, liquid, solid and mixtures, sensible heat change in gas and liquid, enthalpy change in phase transformation, enthalpy change accompanied by biochemical reaction, Standard heat of reaction, heat of mixing and dissolution of solids, Hess's law, Humidity chart, Energy balance involving biochemical reaction.

Case Studies: Flow chart based material and energy balance calculations.

Text Books

1. David M. Himmelblau, James B. Riggs, PHI Learning Pvt. Ltd, 7th edition, 2006. Basic Principles & Calculations in Chemical Engineering",

2. Richard M. Felder, Ronald W. Rousseau, Wiley, 3rd edition, 2004. Elementary Principles of Chemical Processes.

3. Pauline M. Doran. Bioprocess Engineering Principles. 2nd ed. Elsevier Science & Technology Books. 1995.

Reference

1. O.A.Hougen, K.M.Watson, R.A.Ragatz, CBS Publishers New Delhi, 2nd edition, 2004.Chemical Process Principles Part-I: Material and Energy Balances.

Evaluation & Grading

Evaluation will be based on tutorials, quizzes in class along with mid semester and end semester examinations. Grading from AS to DD and F, as per standard grading system followed by institute.

BT 202

Biothermodynamics

L T P C

2 1 0 6

Semester 3, JUL-NOV

Lectures: 28, Tutorials: 14

Pre-requisites

NIL

This course is designed for second year undergraduates (B.Tech).

Objective

The aim of this core course is how thermodynamics can best be applied to applications and processes in biochemical engineering. It describes the rigorous application of thermodynamics in biochemical engineering to rationalize bioprocess development and obviate a substantial fraction of this need for tedious experimental work.

Course Content

Introduction to Thermodynamics: Energy, Energy Transfer, First Law of Thermodynamics, Entropy, Second & Thrid Law of Thermodynamics, Gibbs energy, governing equations for Mass, Energy and Entropy in closed and open systems, Refrigeration

Estimation of Thermodynamic Properties: Interrelation between thermodynamic properties of ideal and real gases; Equation of state, intensive and extensive properties, Interrelation between thermodynamic properties of water, Multi-phase systems, Steam table, Thermodynamic properties of mixture, phase equilibrium, Gibb's phase rule.

Thermodynamic aspects of Biological processes: Heat generation and energy dissipation of live cell growth process, thermodynamic prediction of kinetic parameters (e.g. yield coefficients, growth rate, specific rates, affinity constants), metabolic heat production, Gibbs energy dissipation for aerobic, fermentative and autotrophic cell growth, Biocalorimetry and its applications.

Thermodynamics of Metabolism: Black box thermodynamic analysis of Dicarboxylic acid production (e.g. Fumaric acid, succinic acid), maximum theoretic product yield, alkali consumption, osmotic stress and ionic strength, ATP synthesis for growth, thermodynamic feasibility analysis of metabolic pathways.

Text Books

1. Urs von Stockar, Biothermodynamics: The role of thermodynamics Biochemical Engineering, CRC Press, 2013.

2. Stanley I Sandler, Chemical, Biochemical and Engineering Thermodynamics, 4th Ed., Wiley Publishers, 2006.

References

1.Mustafa Ozilgen, Esra Sorguven, Bio-thermodynamics principles and applications, CRC Press, 2017

2. J.M Smith, H.C Van Ness and M.M Abott, Introduction to Chemical Engineering Thermodynamics, McGraw Hill (4th Ed), 1987.

Evaluation & Grading

Evaluation and Grading will be done as per the standard grading policy of the Institute.

BT 203

Biochemistry

L T P C

3 0 0 6

Semester 3, JUL-NOV

Lectures: 42

Description/Preamble

Biochemistry is one of the key subjects for understanding various processes in a living system, both plants and animals. Biochemistry has enormous role in novel drug discovery and crop improvement. This course is designed to introduce the basic concepts of Biochemistry and metabolism in living system. The objective is to help the students rapidly reach the frontier of Biochemistry and use the concepts for product development in industry and basic research.

Industrial Relevance

Biochemistry allows us to break down the building blocks to its basic form and reorganizes it back in a way that makes useful product in today's market. The subject of biochemistry is closely related to medicine, agriculture and other applied sciences including the pharmaceutical industries. The knowledge of this subject will help to make a strong social contribution in terms of its role in clinical diagnosis, treatment of diseases, manufacture of various biological products, etc.

Objective

To provide a broad understanding of structures function and metabolism of macromolecules, understanding of principles and metabolism of these Macromolecule and molecular signaling.

Pre-requisites

This course is designed for fourth year B.Tech student. Before taking this course, it is expected that the student had cleared BT101 course.

Syllabus

Structure and function of biomolecules : Protein, carbohydrate, lipid; Enzymes: structure, mechanism and reaction kinetics; Basic concept and design of metabolism; carbohydrate metabolism: glycolysis, gluconeogenesis, citric acid cycle, pentose phosphate pathway, glycogen metabolism, oxidative phosphorylation; photosynthesis; Nitrogen fixation; fatty acid metabolism; protein: synthesis, targeting and turnover; biosynthesis of amino acids and nucleotides; Integration of metabolisms; hormones; Introduction to signal transduction pathways

Text Books

1. D. L. Nelson and M. M. Cox, Lehninger Principles of Biochemistry, 6th Ed., Macmillan Worth, 2012.

2. J. L. Tymoczko, J. M. Berg and L. Stryer, Biochemistry, 8th Ed., W. H. Freeman, 2015.

References

1. W. W. Parson, D. E. Vance and G.L.Zubay, Principles of Biochemistry, Wm. C. Brown Publishers, 1995.

2. R. K. Murray, D. K. Granner, P.A. Mayes and V. W. Rodwell, Harper's Biochemistry, 30th Ed McGraw Hill, 2015.

Evaluation & Grading

Evaluation will be based on assignments, quizzes, final and mid semester examination. The assignment will be done as per the existing norms of the institute.

BT 204

Genetics

L T P C

3 0 0 6

Semester 3, JUL- NOV

Lectures: 40-42

Description/Preamble

This course is designed to introduce the basic concepts in genetics. The objective is to help the students get acquainted with classical, modern and quantitative genetics. Deep study of this course would generate curiosity in students as how inheritance of traits occurs, reasons and causes of variations among individuals and occurrences of unavoidable syndromes. One can determine how likely members of the population may inherit a disease and to help people manage their risks accordingly.

Industrial Relevance

The genetics has wide applications in health sector where understanding the developmental pathways may help to unfold the genetical reasons of the disease and aids in finding the cure of it. The contribution of genetics is also important in agriculture and food sector. It may assist in achieving high yield of food crops and animal produce.

Objective

The objective of this course is to take the students through the basics of genetics and classical genetics encompassing higher eukaryotic domains. On covering all classical concepts of Mendelian genetics across these life-forms, the students will be exposed to the concepts of population genetics, quantitative genetics encompassing complex traits and genetics of evolution. On successful completion of this course, the student will be able to supplement their future research on both experimental and clinical projects.

Pre-requisites: None

Syllabus

Genes, chromosome and heredity: Gene- fundamental unit of heredity; Chromosome structure and function; DNA-the genetic material; Molecular organization of chromosomes.

Cell division and cell cycle: Mitosis; Meiosis; Genetic consequences of cell cycle.

Basic principles of heredity: Mendelian genetics: Mendel's experiments, genetic terminology; Mendel's laws of genetics: monohybrid crosses, dihybrid crosses; Deviations of Mendel's ratios; Genetic interactions: epistasis, pleiotropy, penetrance and expressivity, multiple alleles.

Chromosome mutations: Types of mutations; Numerical changes in chromosome: euploidy, aneuploidy; Structural changes in chromosomes: duplications, deletions, inversions, translocations.

Linkage, crossing over and chromosome mapping: Basic principles, Exception to Mendelian law of independent assortment;

linkage intensity: calculating recombination frequency, coupling and repulsion linkages; Crossing over as physical basis of recombination; Gene mapping and recombination frequencies.

Sex determination and Sex-linked characteristics: Chromosomal sex-determining systems; Genic sex-determining systems; Environmental sex-determination; Sex determination in Drosophila melanogaster; Sex determination in Humans; Sex determination in plants; Sex-linked, Sex-influenced and Sex limited traits; Dosage compensation, Y-linked characteristics.

Quantitative Genetics: Quantitative traits; polygenic inheritance; Statistical methods to analyze quantitative characteristics: the mean, the variance and standard deviation, correlation, regression.

Population Genetics: Allelic frequency; Hardy-Weinberg Law and its applications; Natural selection; Mutation; Genetic drift; Migration.

Text Books

1. Klug W. S., Cummings M.R. and Spencer C.A. Concepts of Genetics (8th Ed.). Prentice Hall, New Jersey, USA, 2006.

2. Gardner E. J., Simmons M. J. and Snustad D. P. Principles of Genetics (8th Ed.). John Wiley & Sons Ltd. Singapore, 2006.

Reference

1. Selected papers from scientific journals, particularly Nature & Science.

Evaluation & Grading

Evaluation will be based on marks scored during written exam in class quizzes, mid semester and end semester examinations. Grading from AS to DD and F, as per standard grading system followed by the institute.

BT 205

Cell & Molecular Biology

L T P C

3 0 0 6

Semester 3, JUL-NOV

Lectures: 40-42

Pre-requisites

Modern/Introductory biology (current BT101). This course is designed for third year undergraduates (B.Tech).

Objective

The aim of this core course is to provide a detailed insight into the concepts of molecular biology and its mechanisms that control cell functions along with a sense of its complex regulatory mechanisms.

Course Content

Cell organization and subcellular structures; structure and properties of nucleic acids; organization of prokaryotic and eukaryotic genomes; mechanisms of DNA replication; mechanism of DNA recombination; transcription, eukaryotic RNA splicing and processing; translation; regulation of gene expression; cell signaling; programmed cell death; oncogenes; genes in differentiation and development.

Text Books

1. D. L. Nelson and M. M. Cox, Lehninger Principles of Biochemistry, 6th Ed., Macmillan Worth, 2012.

2. B. Alberts, A. Johnson, J. Lewis, M. Raff, K. Roberts and P. Walter, Molecular Biology of the Cell, 6th Ed., Garland Publishing, 2015.

3. H. Lodish, A. Berk, C. A. Kaiser, M. Krieger, M. P. Scott, A Bretscher, H. Ploegh, and P. Matsudaira, Molecular Cell Biology, 6th Ed., W. H. Freeman & Co., 2007.

References

1. B. Lewin, Genes XI, International Edition, Pearson Education, 2014.

2. B. R. Glick and J.J. Pastemak, Molecular Biotechnology: Principles and applications of recombinant DNA, 4rth Ed., ASM Press, 2010.

3. Jordanka Zlatanova, Kensal van Holde, Molecular Biology, (1st Ed), 2015.

4. Nancy Craig, Rachel Green, Carol Greider, Gisela Storz, Cynthia Wolberger, and Orna Cohen-Fix Molecular Biology, Principles of Genome Function (2nd Ed), 2014.

Evaluation & Grading

Evaluation and Grading will be done as per the standard grading policy of the Institute.

BT 206

Microbiology

L T P C

3 0 0 6

Semester: 4, JAN-MAY

Lectures: 38 - 42

Description/Preamble

This course is designed to introduce various fundamental concepts related to the microbial world. Topics covered will be history, microbial cell structure and function, growth and culturing, microscopic techniques in microbiology, microbial taxonomy, microbial genetics, pathogenicity and disease, eukaryotic microbes and viruses. The objective is to introduce to the students the field of Microbiology and provide them the basic understanding of various concepts.

Industrial Relevance

Discovery and evaluation of different forms of bacteria, fungi, protozoa and viruses constitute the basics of biotechnology. Food industry (fermentation of foods), medicine and healthcare (production of antibiotics, identification of pathogens, etc.), biofuels, metabolite production, wastewater treatment, biopolymers, etc. are only a few to list of the many applications of microbes in industry. Hence knowledge gained from this course will be very relevant for industrial applications.

Objective

To provide a broad understanding of various aspects of Microbiology. To introduce to the students various types of microbes, the tools and techniques used to study microbes and understand the importance of microbes in modern world.

Pre-requisites

NIL

Syllabus

Introduction to microbiology and study of microorganisms: Scope of Microbiology; History of Microbiology: Spontaneous generation; Germ theory of diseases; Cell theory; Contributions of Antonie van Leuwenhoek, Joseph Lister, Robert Koch, Louis Pasteur, Edward Jenner, John Tyndall, Sergei N. Winogradsky, Alexander Fleming, etc; Microbial cell structure and function: General account of cell size, arrangement, shape; capsule, slime, pili, spores; structure and function of gram negative & gram-positive cell wall and membrane; periplasmic space; brief account of viruses; mycoplasma, eukaryotic microbes.

Microbial taxonomy: Taxonomy: principle and its types; classical approach: numerical, chemical, serological and genetic; bacterial taxonomy: Bergey's manual of Systematic Bacteriology (eubacteria and archaebacteria)

Methods and techniques in Microbiology**:** Microscopy: Principles; light microscope, phase contrast, dark field, bright field, fluorescent, interference microscope (stereo microscope); confocal microscopy; electron microscope (TEM and SEM).

Nutrition, growth and culturing: Microbiological media, composition and types; selective and differential media; growth curve, growth kinetics; influence of environmental factors on microbial growth; nutritional groups of bacteria; overview estimation of microbes - direct microscopic count, turbidometric assay; indirect method - CO2 liberation, protein estimation; sterilization and disinfection.

Microbial metabolism**:** Carbohydrate catabolism; anaerobic respiration, fermentation; protein and lipid catabolism; biosynthesis of purines, pyramidines, peptidoglycan, amino acids, lipids.

Microbial genetics: DNA replication in bacteria, fundamentals of gene regulation; mutations and DNA repair; plasmids, transformation, conjugation, transduction; Fundamentals of microbial genomics, metagenomics; Introduction to metagenomics; Scope and applications of genomics and metagenomics;.

Applications/Role of microbes**:** Applications in agriculture; environment; industry; health and disease. microbe interactions; mechanisms of pathogenicity.

Text Books

1.G. Tortora, B. Funke and C. Case,Microbiology,An Introduction (International Edition), 8th Ed, Pearson Education, 2003.

2. M. Madigan, J. Martinko and J. Parker, Brock Biology of Microorganisms, 10th Ed, Prentice Hall, 2002.

References

1. R. Y. Stanier, J. L. Ingraham, M.L. Wheelis and P. R. Painter, General Microbiology, 5th Ed, Macmillan Press, 1987.

2. L. M. Prescott, J. P. Harley and D. A. Klein, Microbiology, 6th Ed, McGraw Hill, 2005.

3. J. G. Black, Microbiology: Principles & Explorations. 5th Ed, John Wiley & Sons Inc., 2002.

4. Benjamin Lewin, Genes VIII (International Edition), Pearson Education, 2004.

Evaluation & Grading

Evaluation will be based on assignments, quiz, mid semester and end semester examinations. Grading from AS to DD and F, as per standard grading system followed by institute.

BT 207

Genetic Engineering

L T P C

3 0 0 6

Semester 4, JAN-MAY

Lectures: 40-42

Description/Preamble

This course is designed to introduce the basic concepts and methods employed in genetic engineering. This course includes topics on various tools and techniques used in genetic engineering for research or therapy. The recent advances in genetic engineering using several DNA modifying enzymes for precision gene editing which has immense applications in treatment of diseases is included in the course. The use of bioinformatics analysis to understand gene expression and regulation will also be covered in this course.

Industrial Relevance

Several diseases are caused by inherited or acquired changes in the genome. Therapeutic options developed through genetic engineering is already being pursued and tested for several human diseases across the globe. Introduction of useful traits (pest resistance, drought resistance, higher yield, etc.) are carried out for several useful crop plants through genetic engineering. So, a good understanding of the genetic engineering tools and methods will make the students ready for a career in genetic engineering.

Objective

To provide a good understanding of tools and techniques used in genetic engineering. To understand the concepts behind gene expression modification for disease treatment and crop improvement.

Pre-requisites

Nil

Syllabus

The basis of genetic engineering: Genome organization; the flow of genetic information; Genes and genomes; Genome size and complexity; The transcriptome and proteome. Labelling nucleic acids; End labelling; Nick translation; Labelling by primer extension; Nucleic acid hybridization. DNA sequencing; Principles of DNA sequencing; Next-Gen sequencing. Human Genome Project.

Techniques in Genetic Engineering: DNA/ RNA extraction, Polymerase Chain reaction: primer design, Nested PCR, inverse PCR, RAPD, Real-time PCR. Gel Electrophoresis-DNA, RNA and Protein. Blotting: DNA, RNA and Protein. Site directed mutagenesis, DNA/ Protein interactions: CHIP, EMSA, Reporter assays, pull down assays.

DNA modifying enzymes and vectors: Nucleases; Polymerases; Enzymes that modify the ends of DNA molecules: Terminal Transferase, T4 Polynucleotide Kinase, Alkaline Phosphatases; DNA ligase, Restriction enzymes. Vectors for cloning and expression in prokaryotes and Eukaryotes: Plasmid Vectors,

Phage Vectors, Cosmids, Phagemids, BACs, Yeast
Vectors, YACs, Lentiviral Vectors, Adenoviral Vectors, Plant Vectors, Insect Vectors. In-frame protein fusion and use of GFP for subcellular localization of protein/DNA. cDNA and genomic DNA library construction. Introduction of foreign DNA: Transfection, transformation, particle gun and Ti plasmid mediated.
Recent advances and applications: ZFNs, TALENs, CRISPR/Cas systems. Transgenic plants and animals, gene therapy, forensic applications.
Bioinformatics: DNA and protein databases. Promoter identification, Gene expression analysis, Big data analysis.

Text Books

1. Desmond S. T. Nicholl, An Introduction to Genetic Engineering (3rd Ed), Cambridge University Press, 2010.
2. T. A. Brown, Gene Cloning and DNA Analysis: An Introduction, (6th Ed), Wiley-Blackwell, 2012.
3. Sandy B. Primrose, Richard Twyman, Principles of Gene Manipulation and Genomics, (8th Ed), Blackwell Publishing, 2016
4. Michael R. Green and Joseph Sambrook, Molecular Cloning: A Laboratory Manual, (4th Ed), Cold Spring Harbor Laboratory Press, 2012.

References

1. Bernard R. Glick, Jack J. Pasternak, Cheryl L. Patten, Molecular Biotechnology: Principles and Applications of Recombinant DNA (4th Ed), ASM Press, 2010.
2. T.A. Brown, Introduction to Genetics: A Molecular Approach, (1st Ed), Garland Science, 2011.
3. Jordanka Zlatanova, Kensal van Holde, Molecular Biology, (1st Ed), 2015

Evaluation & Grading

Evaluation will be based on marks scored during written exam in class quizzes, mid semester and end semester examinations. Grading from AS to DD and F, as per standard grading system followed by the institute.

BT 208

Transport Phenomenon in Bioprocesses

L T P C

3 1 0 8

Semester 4, JAN-MAY

Lectures: 28, Tutorials: 14

Description/Preamble

This course is designed to provide students with an introduction to the basic transport phenomena required to analyze and design bioprocess systems. Overall focus is on the development of a physical understanding of the underlying momentum/heat/mass transport phenomena and upon the ability to apply transport analysis to practical bioprocess-oriented problems.

Objective

This course aims to provide students an understanding of conservation laws and constitutive equations as they apply to convective and diffusive transport of mass, heat and momentum. Enable students to solve simple diffusion, heat conduction and fluid flow problems using the transport equations, to be able to be conversant in the topic with other engineers. Learning outcomes of this course are:

- Mathematically analyze and interpret given experimental data on a simple flow-related problem and provide a physical explanation of the results obtained. Design a generic flow system by verification of the assumptions made and quantify the pump requirements.
- Calculating the power input required for agitation in stirred-tank fermenter under a range of operating conditions.
- Defining conditions for the successful scale-up or scale-down of a fermentation process
- Key design features that determine the heat transfer.
- Defining conditions for the successful scale-up or scale-down of a fermentation process
- Evaluating the consequences of process changes on the performance of fermenter sterilization and cooling.
- Designing a spray drier for rapid drying of heat-labile proteins
- Defining conditions for successful operation of a freeze drying process.
- The basis for dispersion and mass transfer within packed bed chromatography systems.

Pre-requisites

Not required

Syllabus

The course content is subdivided into momentum transfer, heat transfer and mass transfer:

Momentum transfer:

Introduction and rheology: Definition of transport processes. Basic and derived units and nomenclature. Dimensionless numbers. General aspects of rheology. Newton's Law. Non-Newtonian fluids and rheology of fermentation broths. Viscosity measurement. Case study.

Fluid flow in pipes: Predicting flow characteristics in pipe systems. Laminar flow and Hagen-Poiseuille equation. Calculating heads in a pipework system. Bernoulli equation. Case study: Bernoulli design problem. Pumping of Liquids (pumps classification, NPSH, cavitation, characteristic curve), Compressor. Flow and pressure measurement.

Fluid flow in packed-bed and Fluidized bed columns: Flow through porous media. Darcy's Law and Carman-Kozeny equation. Determining column porosity. Estimating pressure drops in packed beds. Effect of particle shape. Concept of wall support and effects of compressible media. Concept of critical velocity.

Heat transfer

Introduction: Mechanisms and applications of heat transfer -mode of heat transfer-conduction, convection and radiation.

Steady state heat transfer fundamentals: Resistances to heat transfer. Heat transfer in heat exchangers and fermenter coils, jacketed vessels. Principles of heat transfer underlying condensation and evaporation. Unsteady state heat transfer fundamentals.

Mass Transfer:

Diffusion and Mass transfer coefficient: Diffusivity and mechanism of mass transfer - derivation of the equations of mass transport by diffusion-stationary and unsteady mass transport by diffusion-convective mass transport-mass transfer coefficient, macroscopic balances for mass transport.

Application of Heat and Mass transfer: Absorption, Distillation principles, phase diagrams and equilibrium curves, non-ideal systems, continuous distillation, McCabe - Thiele method, column operation. Drying principles and operation.

Text Books

1. Transport Phenomena, by Bird R.B., Steward W.E., and Lightfoot E.N., John Wiley & sons, Inc., New York, 2002

2. C J Geankoplis, Transport Processes and Separation Processes Principles, 4th Edition, New Jersey, PHI Publishers, 2010

3. Pauline M. Doran. Bioprocess Engineering Principles. 2nd ed. Elsevier Science & Technology Books. 1995

References

1. Bailey, J. E., and D. F. Ollis. Biochemical Engineering Fundamentals. 2nd ed. New York, McGraw-Hill, 1986.

2. H. W. Blanch and D. S. Clark, Biochemical Engineering, Marcel, Dekker Inc., 1996.

Evaluation & Grading

Evaluation will be based on tutorials, quizes in class along with mid semester and end semester examinations. Grading from AS to DD and F, as per standard grading system followed by institute.

BT 209

Bioreaction Engineering

L T P C

2 1 0 6

Semester 4, JAN-MAY

Lectures: 28, Tutorials: 14

Description/Preamble

This course is designed to provide the concepts of the reaction rate, stoichiometry and equilibrium to the analysis of chemical/biochemical reacting systems, determine of rate expressions from experimental data, process design of reactors and product distribution of multiple reaction for homogeneous reaction. Topic covered include; reaction kinetics, rate expression, ideal batch, continuous stirred tank reactors, plug flow reactor, design for single and multiple homogeneous reaction in single and combination of multiple reactors, autocatalytic reaction such as cell growth, temperature effect on product distribution and non-ideal reactors.

Industrial Relevance

Selection of right kind of reactor or combination of reactors and reactor operation play a major role in the efficient or cost effective production of biological product such as enzyme, therapeutics, health supplements, biofuel etc. in the bioprocess industry. This course will help to understand the reaction kinetics, choosing the reactor(s) based of product yield /selectivity and analysis of non-ideality of the reactor. All above mention things will give the basic idea for reactor design and development of novel bioreactor for production of bio-product in cost effective manner in biochemical industry.

Objective

Student will understand the concept of batch and flow reactor design for homogeneous/ heterogeneous reactions

Pre-requisites

Not Required

Syllabus

Kinetics of bioreaction: Bioreaction stoichiometry, Lumped stoichiometry in complex systems such as enzymatic bioconversions and cell growth, Homogeneous/Heterogeneous bioreaction, Molecularity, Order, Rate of bioreaction, Elementary and non-elementary bioreaction, Single reactions and reaction networks, Bioreaction network, Reactive intermediates and steady state approximation in bioreaction mechanisms, Rate-limiting step.

Rate of bioreaction parameters: Conversion, Experimental data collection and analysis to determine the kinetic parameters for reversible and irreversible bioreactions, Shifting order bioreaction, Temperature effect on rate of bioreaction, Arrhenius equation.

Ideal bioreactors: Introduction of bioreactor design: concept of ideal Batch and ideal steady state continuous bioreactors: Continuous stirred tank state bioreactor (CSTR) and plug flow bioreactor (PFR).

Design for Single bioreactions: Size comparison of bioreactors: single bioreactors for single reaction, Series and parallel combination of multiple bioreactors for single reaction, Recycle bioreactor, Autocatalytic reaction such as biomass growth. Product distribution and Design for Multiple bioreactions: Multiple bioreaction: series and parallel bioreaction, Design for parallel bioreactions, product distribution, yields, selectivity and bioreactor size, Design for series reaction and successive reactions of shifting orders in different reactors, Combination of irreversible series and parallel bioreaction.

Heterogeneous bioreaction: Heterogeneous reaction in bioprocessing, immobilization of cell and enzyme, concentration gradient and reaction rates in immobilized cell and enzyme, internal mass transfer and bioreaction, Thiele modulus and effectiveness factor, external mass transfer.

Non-Ideal bioreactor mixing patterns**:** Basics of non-ideal flow, E, the age distribution of fluid, Residence time distribution (RTD), prediction of conversion, Reactor modeling with RTD, Segregation model, Tanks in series model, Dispersion model.

Text Books

1. O. Levenspiel, Chemical Reaction Engineering, 3rd Ed., John Wiley & Sons, Inc. 1999.

2. Doran, Bioprocess Engineering Principles, 2nd Edition, Academic Press, 2014

References

1. H. S. Fogler, Elements of Chemical Reaction Engineering, Prentice Hall, 2nd Ed., New Jersey, 1992.

2. J. Smith, "Chemical Engineering Kinetics", 3rd edition. McGraw-Hill, (1990).

3. Bailey, J. E., and D. F. Ollis. Biochemical Engineering Fundamentals. 2nd ed. New York, McGraw-Hill, 1986.

Evaluation & Grading

Evaluation will be based on assignments and hour examination like quiz in class along with mid semester and end semester examinations. Grading from AS to DD and F, as per standard grading system followed by institute.

BT 211

Basic Biotechnology Laboratory

L T P C

0 0 6 6

Semester 4, JAN-MAY

Lab Sessions: 28

Description/Preamble

The course is designed to introduce the basic laboratory techniques. It would give a hands on experience to the students to carry out various experiments related to the fields of microbiology, cell and molecular biology. The experiments include aseptic techniques for microbial culture, isolation and quantification of viable cells; transformation studies in E.coli, estimation of DNA, carbohydrate and protein. The other experiments include the techniques like ELISA, gel electrophoresis and enzyme kinetics. The objective is to expose the students to these simple experiments which are very essential to carry out day to day research activities in the laboratory.

Industrial Relevance

Nil

Objective

This course is designed to expose the students to basic laboratory techniques in the fields of microbiology, cell and molecular biology. Hands on experience with these would help them deal with other biotechnological experiments in the fields of Analytical biotechnology, Biochemical and Bioprocess engineering. The exposure to all these fields would truly enhance their knowledge which may help the student for their future research problems, both for their B.Tech as well as future research in MS or Ph.D.

Pre-requisites:

Nil

Syllabus

Theory, Operation and handling of instruments to be used in the lab course; Aseptic techniques for microbial culture; isolation of pure microbial culture and quantification of viable cells; Gram staining technique; preparation of chemically competent E.coli cells; Transformation of E.coli; small scale isolation of Recombinant plasmid from E.coli; analysis of the recombinant plasmid using Restriction enzymes; RNA isolation; Polymerase Chain Reaction; Estimation of DNA in solution; Estimation of protein in solution; Estimation of carbohydrate; Enzyme linked Immuno assay; Gel electrophoresis of protein; study of enzyme kinetics.

Text Books

1. R. Boyer, Modern Experimental Biochemistry, 3rd Ed., Pearson Education (Singapore) Pvt. Ltd., 2001

2. R. L. Switzer and L. F. Garrity, Experimental Biochemistry, 3rd Ed., W. H. Freeman, 1999

3. S. J. Karcher, Molecular Biology: A Project Approach, Academic Press, 2001.

References

1. J. Sambrook, D. W. Russell and J. Sambrook, Molecular Cloning, A laboratory Manual, Cold Spring Harbor Laboratory, USA, 1999.

2. J. G. Chirikjian, Biotechnology: Theory and Techniques (Genetic Engineering, Mutagenesis and Separation Technology), Jones & Bartlett Publishers, U.K., 1995.

3. H. Jones and John M. Walker, Plant Gene Transfer and Expression Protocols: Methods in Molecular Biology, 49, Humana Press, 1996.

4. J.G.Chirikjian, Biotechnology: Theory and Techniques (Plant Biotechnology, Animal Cell Culture and Immunobiotechnology), Jones & Bartlett Publishers, U.K., 1996.

5. D. M. Glover and B. D Hames, DNA Cloning II, IRL Press, 1995.

6. K. Wilson and J. Walker (ed.), Practical Biochemistry, Principles and Techniques, Cambridge University Press, 1995.

Evaluation & Grading

Evaluation will be based on lab exercises along with mid semester and end semester examinations. Grading from AS to DD and F, as per standard grading system followed by institute.

BT 301

Biophysics

L T P C

2 1 0 6

Semester 5, JUL-NOV

Lectures: 28, Tutorials: 14

Description/Preamble

Biophysics is an interdisciplinary area that applies the concepts and principles of physical sciences to study biological systems. This course is intended to provide an introduction to the theory underlying various physical methods and their applications towards solving biological problems. The topics include an introduction to thermodynamics, structures of biological macromolecules and the physical methods to study these structures, and membrane biophysics.

Industrial Relevance

A large component of the course deals with the characterization of biological molecules, largely proteins, for their structure and dynamics. This finds direct applications in pharmaceutical industry as proteins happen to be the targets of most drugs. Approximately 50% of the drug molecules known today act at the membrane proteins; the syllabus includes a distinct section on membrane biophysics, a topic that is usually not taught as a separate course. Knowledge of membrane structure, composition, and function is highly desirable if discovering novel drugs is the aim. Protein folding, unfolding, and misfolding constitute an important section of the course. Protein misfolding and aggregation is a major concern in the pharmaceutical industry. Optimizing the methods for the production of protein/ peptide drug molecules needs the understanding of principles underlying protein folding/misfolding and aggregation. Many of the peptide drugs have the tendency to aggregate that could render the drugs inactive or even toxic. Development of the stable protein/peptide based drug formulation, therefore, is a major challenge in pharmaceutical industry.

Objective

To enable the students look at the biological sciences questions from a physical science perspective and design the experiments to answer those questions.

Pre-requisites

Basic biology, biochemistry, and mathematics at least up to 10+2 level

Syllabus

Molecular potentials: bonding, nonbonding; water as a solvent: unusual physical properties, hydrogen bonding, ionization, and concept of pH; structures of bio-macromolecules: proteins, polynucleotides, and carbohydrates

Introduction to thermodynamics, statistical mechanics, and kinetics: Principles of probability, introduction to thermodynamics and statistical mechanics, random walk, diffusion, polymer conformation, chemical kinetics: energy, entropy, rate theory.

Methods in molecular biophysics: UV/Vis absorption spectroscopy, fluorescence spectroscopy, circular dichroism spectroscopy, isothermal titration calorimetry, and mass spectrometry.

Protein folding, unfolding, misfolding, and aggregation: Introduction to the protein folding problem, Anfinsen's experiment, Levinthal's paradox, Intermediates and folding pathways, Energy landscape theory and folding funnel; folding in vivo: molecular chaperones, intrinsically disordered proteins; protein unfolding, protein misfolding and aggregation: amyloid diseases and stability of protein/peptide drug formulations.

Membrane biophysics**:** Structure of lipids and their assembly, structure and properties of biological membranes, membrane curvature, membrane transport processes, biophysics of ion channels, model membranes: liposomes, supported bilayers, lipid monolayers.

Text Books

1. Kensal E Van Holde, Curtis Johnson and Pui Shing Ho. Principles of Physical Biochemistry, Pearson Prentice Hall; 2 edition, 2005

2. Rodney Cotterill. Biophysics - An Introduction, Wiley, 2014

References

1. Ken A. Dill and Sarina Bromberg. Molecular Driving Forces: Statistical Thermodynamics in Biology, Chemistry, Physics, and Nanoscience, Garland Science; 2nd Edition, 2010

2. Charles R. Cantor and Paul R. Schimmel. Biophysical Chemistry, Parts 1-3, W. H. Freeman, 1980

3. Thomas E. Creighton. Proteins: Structures and Molecular Properties, W. H. Freeman, 1992.

4. Thomas Nordlund. Quantitative Understanding of Biosystems: An Introduction to Biophysics. CRC Press, 2011.

5. Bengt Nolting, Methods in Modern Biophysics, Springer Verlag, 2004

Evaluation & Grading

Evaluation will be based on assignments, lab exercises and small projects along with mid semester and end semester examinations. Grading from AS to DD and F, as per standard grading system followed by institute.

BT 302

Bioinformatics

L T P C

2 0 2 6

Semester 5, JUL-NOV

Lectures: 28, Lab Sessions: 14

Description/Preamble

This course is designed to introduce the basic concepts and methods employed in Bioinformatics through hands on learning experiences. Topics include sequence based homology detection, gene prediction, phylogenetic analysis, etc. with clear emphasis on the understanding and utilization of concepts and algorithms. The objective is to help the students rapidly reach the frontier of Bioinformatics and use standard tools to solve problems in modern biology.

Industrial Relevance

The advent of genomic era heralds an ever-expanding deluge of biomedical information concerning human health and wellbeing. Computational approaches contribute immensely to glean these large volumes of biological data for devising suitable therapeutic interventions. Global healthcare is a trillion dollar industry. However, cost of developing a new drug from concept to market is projected to be around 35000 crore rupees (5 billion US dollars) with a success rate in clinical phase approval remain at a mere 12 %. Such 'drug failures' are key contributors to development costs. Computational methodologies have therefore become a crucial component for many drug discovery programs, especially in the early stages of the pipeline to minimize this exorbitant cost and verify transition probabilities from phase to phase using *in silico* prediction tools. Undergraduate students in IIT are good in their quantitative skills and engineering practices. A good training in computational methods can make them more employable and complement current industry strategy aimed at accelerating and economizing discovery and development process. India already has a matured information technology platform in place, which can potentially supplement computational drug discovery initiatives, but not exploited effectively till date. Development of new solutions demand trained personnel who have a good understanding of the operational principles in biology along with computer aided design to effectively supplement industrial research.

Objective

To provide a broad understanding of computational techniques and resources available to biological scientists. Student should be able to supplement their future research on both experimental and computational projects with this training.

Pre-requisites

This course is designed for advanced undergraduates with reasonably strong backgrounds in molecular biology, mathematics, and computer science, but not necessarily all.

Syllabus

Introduction to biological databases: collection, organization, storage and retrieval of data; Concept of homology and definition of associated terms; Pairwise sequence alignment: dynamic programming algorithm, global (Needleman-Wunsch) and local (Smith-Waterman) alignments; BLAST Scoring matrices (PAM and BLOSUM families), gap penalty, statistical significance of alignment; Multiple sequence alignment: progressive alignment, iterative alignment, Sum-of-pairs method, CLUSTAL W; Pattern recognition in protein and DNA sequences, Hidden Markov Model, Profile construction and searching, PSI-BLAST; Big data analysis: Introduction to Next-generation sequencing analysis, RNA-seq, CHIP-seq, Introduction to phylogeny: maximum parsimony method, distance method (neighbor-joining), maximum-likelihood method; Gene prediction in prokaryotes and eukaryotes, homology and ab-initio methods; Genome analysis and annotation; comparative genomics, cluster of orthologous groups.

Text Books/References

1. Marketa Zvelebil, Jeremy O. Baum. Understanding Bioinformatics. Garland Science, 2007.

2. Mount, David W. Bioinformatics: Sequence and Genome Analysis (2nd Ed.). CSH press, 2005

3. Bourne, Philip E. Structural Bioinformatics. (2nd Ed.). Wiley, 2009.

4. Richard Durbin, Sean R. Eddy, Anders Krogh, Graeme Mitchison. Biological Sequence Analysis. Cambridge University Press, 1998.

5. Kochan, Stephen G; Wood, Patrick. UNIX shell programming (3rd Ed.). SAMS, 2003.

Evaluation & Grading

Evaluation will be based on assignments, lab exercises and small projects along with mid semester and end semester examinations. Grading from AS to DD and F, as per standard grading system followed by institute.

BT 303

Biochemical Engineering

L T P C

2 1 0 6

Semester 5, JUL-NOV

Lectures: 28, Tutorials: 14

Description/Preamble

This course is concerned with conducting biological processes on an industrial scale. The course will aim at coupling biological sciences with chemical engineering. Topics include Enzyme kinetics, Immobilization, Microbial growth kinetics, Stoichiometry, bioreactor operation with emphasis on transport phenomena, reactor control, product separation, and reactor design and scale up.

Objective

This course aims to introduce the students to key concepts in microbiology and biochemistry that reinforce their application in biochemical engineering, including coverage of microbial and biochemical applications. The students will be acquainted with the demonstration of microbial and biochemical processes within the framework of engineering systems and processes.

Pre-requisites

Not required

Syllabus

Introduction to the field, definitions and concepts.

The kinetics of enzyme catalyzed reactions**:** Enzyme-substrate complex and enzyme action, simple enzyme kinetics with one or two substrates, determination of elementary-step rate constant, patterns of substrates concentration dependence, modulation and regulation of enzyme activity, inhibition kinetics, enzyme

Engineering deactivation, enzyme reaction in heterogeneous systems.

Applied enzyme catalysis: Application of hydrolytic enzymes, other applications of enzymes in solution, immobilized-enzyme technology, immobilized enzyme kinetics.

Metabolic stoichiometry and energetics**;** thermodynamic principles, metabolic reaction coupling: ATP and NAD, carbon catabolism, respiration, photosynthesis, biosynthesis, transport across cell membrane, metabolic organization and regulation, end products metabolism, stoichiometry of cell growth and product formation.

Kinetics of substrate utilization, product formation and biomass production in cell cultures: kinetics measurements, kinetics of balanced growth, transient growth kinetics, product formation kinetics.

Gas-Liquid mass transfer and heat transfer in bioprocess systems: Gas-liquid mass transfer in cellular systems, determination of oxygen transfer rates, overall kLa estimates and power requirements for sparged and agitated vessel, factors affecting kLa, non-newtonian fluids, heat transfer, sterilization

Design and analysis of biological reactors**:** Batch, fed-batch and continuous (CSTR and plug flow) operation modes, continuous with cell recycle, immobilized biocatalysis, multiphase bioreactors (packed bed, bubble column, air lift and membrane bioreactor), anaerobic fermentation technology, animal and plant cell reactor technology. Instrumentation and control: physical, chemical and biosensors, online sensors, computers and interfaces Bioprocess scale up and economics.

Text Books

1. Bailey, J. E., and D. F. Ollis. Biochemical Engineering Fundamentals. 2nd ed. New York, McGraw-Hill, 1986.

2. Pauline M. Doran. Bioprocess Engineering Principles. 2nd ed. Elsevier Science & Technology Books. 1995

3. H. W. Blanch and D. S. Clark, Biochemical Engineering, Marcel, Dekker Inc., 1996.

References

1. "Principle of Fermentation Technology", P.F. Stanbury and A. Whitaker; Pergamon Press.

2. "Immobilized Cells and Organelles" Vol. I; B. Mattiason, CRC Press, Florida.

3. Shuler, M. L.; Kargi, F. Bioprocess Engineering: Basic Concepts, (2nd Ed.), Prentice Hall, 2002.

Evaluation & Grading

Evaluation will be based on tutorials, quizes in class along with mid semester and end semester examinations. Grading from AS to DD and F, as per standard grading system followed by institute.

BT 304

Immunology

L T P C

3 0 0 6

Semester 5, JUL-NOV

Lectures: 42

Prologue

This course is designed to introduce the basic understanding of immunological processes and mechanisms, how they contribute to disease and how can they be manipulated therapeutically. Topics include innate immunity, adaptive immunity, immunologic tolerance, autoimmunity, hypersensitivity, immune-deficiencies etc. with clear emphasis on the understanding and utilization of concepts and mechanisms. The objective is to focus on the molecules, cells, organs and genes of the immune system, their interaction and how they are activated and regulated. This would help students to understand the fundamentals of molecular and cellular immunology and highlight the progress and intellectual challenges in this discipline.

Importance

The study of immunology is critical to human and animal health and survival. It is at the cutting edge of medical science and has led to some key healthcare advances of recent times, including vaccination and cancer immunotherapy. Immunologists are developing new treatments to some of the major diseases affecting mankind, including infectious diseases (such as influenza and Ebola), autoimmune conditions (such as type 1 diabetes) and a variety of cancers. The immune system is incredibly complex and we still have lots more to find out about how it works. Classical immunological research has been mainly devoted to natural defense mechanisms against infections and to the development and action of vaccines. With the discovery of immune tolerance and following investigations on transplantation immunity, the concept of the immune response was generalized as the higher animal's ability to discriminate between "self" and "notself". Since then research has concentrated on cells and their products involved in these immune phenomena. Application of the vast knowledge in the field of modern immunology should aid greatly in the solution of many actual clinical problems and in alleviating public health hazards (parasitology, etc.) in the Third World.

Development of new solutions to tackle increasing health issues in India demand trained personnel who have a good understanding of the operational principles in immunology along with in-depth knowledge in modern methodologies, experimental design, data handling and basic research skills to effectively supplement immunology/biomedical research.

Objective

To provide an elemental understanding of the study of development, anatomy functions and malfunctions of the immune system, all of which are of fundamental importance to the understanding of human disease.

Pre-requisites

This course is designed for undergraduates with reasonable backgrounds in basic and molecular biology, but not necessarily all.

Syllabus

Properties and Overview of Immune Responses Cells and Tissue of the immune system, Leukocyte migration into tissues, Antibodies and antigen.

Innate Immunity**:** Major histocompatability complex. Antigen processing and presentation to T lymphocyte. Antigen receptors gene rearrangement and lymphocyte development, Immune receptors and signal transduction, Activation of T lymphocytes.

Adaptive Immunity: Effector mechanisms, B cell activation and antibody production, Regional Immunity, Immune memory response.

Immunologic Tolerance**:** Autoimmunity, Immunity to Microbes, Transplantation immunology, Tumor Immunology.

Hypersensitivity**:** IgE dependent Immune response, Allergic disease, Congenital and acquired immune deficiencies.

Text Books

1. Cellular and Molecular Immunology: 7th Updated Edition by Abul K. Abbas Andrew H. Lichtman & Shiv Pillai.

2. Veterinary Immunology: 7th Edition by Ian R Tizard.

3. Kuby Immunology. 4th Edition by W. H. Freeman & Co., 2000.

4. How the immune system works, by Lauren Sompayrac. Blackwell Science, 1999.

5. Immnology, by William L. Anderson. Fence Creek Publishing (Blackwell), 1999

6. Immunobiology - the immune system in health and disease, by Charles Janeway, Jr. and Paul Travers. Garland Publishing, Inc. Fifth edition, 2001.

7. Immunology by Ivan Roitt, Jonathan Brostoff, and David Male. Mosby, London. 6th edition, 2001.

8. Basic Immunology by Abul K. Abbas and Andrew H. Lichtman, Saunders, 2001

Evaluation & Grading

Evaluation will be based on assignments, lab exercises and small projects along with mid semester and end semester examinations. Grading from AS to DD and F, as per standard grading system.

BT 311

Biochemical Engineering Laboratory

L T P C
0 0 6 6
Semester 5, JUL-NOV
Lab Sessions: 28-32

Description/Preamble

Biochemical Engineering Laboratory course has been designed keeping in view the theoretical aspects to be taught in the subject "Biochemical Engineering". Theoretical aspects of heterogeneous system such as immobilized cell for enzymatic activity, bioreactor operation including mass transfer, transport phenomena, reactor detailing and control operations will be elucidated in Biochemical Engineering subject. To that end, the laboratory module has been designed to provide the students a better in-depth understanding of the theory via experimental detailing. In addition, downstream processing is the need of the hour for industrial applications, so distillation has been subsequently added as the recovery process for fermentation.

Current global scenario and consumption patterns require a sustainable approach to fermentation. Inculcating such an approach into our experimental module, pretreatment of lignocellulosic biomass has been added and subsequent enzymatic hydrolysis of cellulose. This aligns the practical course with current research standards globally.

Objective

Student will understand the concept of pretreatment of biomass, enzymatic kinetics, immobilization techniques, batch and fed batch mode of cultivation.

Pre-requisites

Basic concepts of batch and fed batch mode of cultivation, enzyme kinetics and transport reactions.

Syllabus

Overview: Understanding the different components of a bioreactor and general overview of laboratory equipment's, handling and guidance: To demonstrate the physical components of a working automated bioreactor and elucidate the role and functioning of different parts. It also aims to provide an insight into the functioning and handling of instruments required for various analysis and assay protocols.

1. Production of hydrolytic enzymes (cellulase/hemicellulase) in shake flask: Profiling of substrate uptake rate and specific growth rate.

2. Determination of activity of hydrolytic enzyme: Important to pretreatment is the successful conversion of cellulose to readily utilizable glucose, for which the enzyme cellulose scan be used. Successful conversion and study on the enzyme efficiency will enhance the understanding onwards process development.

3. Free v/s immobilized enzyme kinetics: Immobilization provides an enhanced surface area for activity of enzyme and thus increasing the activity of the specified activity. It also ensures reuse of the immobilized enzyme

4. Pretreatment and enzymatic hydrolysis of lignocellulosic biomass: The cellulose and hemicellulose fractions of the biomass needed to be easily accessible for the hydrolysis. Suitable pretreatment method needs to be employed to remove the lignin fractions from biomass. Pretreatment efficiency will be assessed by extent of lignin removal and cellulose estimation. Subsequently pretreated biomass will be hydrolyzed by the enzymes to release sugars.

5. Estimation of mass transfer coefficient and mixing time in a bioreactor

6. Batch cultivation of *S. cerevisiae* in bioreactor: Profiling of specific growth rate, substrate uptake rate and product formation rate.

7. Fed-batch cultivation of *S. cerevisiae* in bioreactor: Profiling of specific growth rate, substrate uptake rate and product formation rate

8. Downstream processing for ethanol recovery by distillation and quantification of distillation efficiency: Recovery of ethanol through a proper distillation set-up and also quantifying the recovery efficiency.

Text Books

1. O. Levenspiel, Chemical Reaction Engineering, 3rd Ed., John Wiley & Sons, Inc. 1999.

2. Bailey, J. E., and D. F. Ollis. Biochemical Engineering Fundamentals. 2nd ed. New York, McGraw-Hill, 1986.

3. H. W. Blanch and D. S. Clark, Biochemical Engineering, Marcel, Dekker Inc., 1996

References

1. Viet, T.Q., Immobilization of cellulose enzyme in calcium alginate gel and its immobilized stability. American Journal of Research Communication.

2. H. J. Rehm and G. Reed., Biotechnology - A Multi-volume Comprehensive Treatise, Vol.3, 2nd Ed., VCH, 1993.

3. M. Moo-Young, Comprehensive Biotechnology, Vol 2, Pergamon Press, 2004

4. P. F. Stanbury and A. Whitaker, Principles of fermentation technology, Pergamon Press, 1984

5. S. Aiba, A. E. Humphrey and N. Millis, Biochemical Engineering, Prentice-Hall 1978

Evaluation & Grading

Evaluation and grading will be based on laboratory attendance and experiments, along with timely report submission, mid semester and end semester examination.

BT 312

Analytical Biotechnology Laboratory

L T P C

0 0 6 6

Semester 5, JUL-NOV

Lab Sessions: 28-32

Description/Preamble

This course aims to provide the detailed guidelines and procedures for carrying out various biotechnological experiments and analyzing the results obtained. The experiments include estimation of biomolecules, especially proteins and nucleic acids; separation, purification, and characterization of the biomolecules; studying biomolecular interactions using spectroscopic and immunological assays; studying the structure of cell and its components; and certain experiments related to nanotechnology and high end instruments. The objective is to introduce the utility of analytical tools and their potentials to solve problems in discovery research.

Industrial Relevance

Biotechnology industry in India has largely focused on production, characterization and development of products relevant to healthcare, petrochemical and pharma industry. All these industries very heavily invest in analytical instruments for their R&D activities. Undergraduate students in IIT are good in their quantitative skills and engineering practices. A good training of analytical instruments and methods can make them more employable and complement current industry strategy aimed at accelerating and economizing discovery and development process. Development of new solutions demand trained personnel who have a good understanding of the operational principles in biology to effectively supplement industrial research.

Objective

To provide a broad understanding of analytical techniques and approaches used to solve complex biological problems. The current course content may enhance the knowledge of the student in the field of biochemistry, immunology, cell and molecular biology and imaging. It may help student to utilize this knowledge for their future research problems, both for their BTech project as well as for future research in Ph.D.

Pre-requisites

This course is designed for advanced undergraduates with reasonably strong backgrounds in biochemistry, molecular biology, immunology, imaging techniques and material science, but not necessarily all.

Syllabus

Theory, operation and handling of instruments to be used in this Lab course, (1) Identification and determination of concentration of amino acid using thin layer chromatograhy, (2) Determination of oligomeric status of the given protein by gel filtration chromatography, (3) monitor equilibrium unfolding of a protein from the tryptophan fluorescence or Far UV-Circular Dichroism or enzymatic assay, (4) Determination of Protein concentration by Bradford method, (5) Immuno-labeling and visualization of marker protein inside cells, (6) Screening of antibodies in radial immuno-diffusion assay, (7) determination of concentration of antibody by ELISA, (8) Preparation of nanoparticle to detect bio-analyte, (9) Demonstration of Flow cytometry with experimental sample, (10) Demonstration of Real-time PCR with experimental sample, (11) Basics of Microscopy with visualization of mammalian cells (unstained and stained sample), (12) Demonstration of SEM with experimental sample and (13) Demonstration of AFM with experimental sample.

Text Books

1. R. Boyer, Modern Experimental Biochemistry, 3rd Ed., Pearson Education (Singapore) Pvt. Ltd., 2001.

2. R. L. Switzer and L. F. Garrity, Experimental Biochemistry, 3rd Ed., W. H. Freeman, 1999.

3. J. Sambrook and D. W. Russell, Molecular Cloning: A Laboratory Manual, Cold Spring Harbor Laboratory Press, 3rd Edition, 2001.

4. Live Cell Imaging: A Laboratory Manual R. D. Goldman, J. R. Swedlow and D. L. Spector Cold Spring.Harbor Laboratory Press; 2nd edition, 2009

5. A. Manz, N. Pamme and D. Iossifidis, Bioanalytical Chemistry, World Scientific Publishing Company, 2004.

References

1. K. Wilson and J. Walker (ed.), Practical Biochemistry, Principles and Techniques, Cambridge University Press, 1995.

2. A. J. Ninfa and D. P. Ballou, Fundamental Laboratory Approaches for Biochemistry and Biotechnology, Wiley; 2nd Edition,1998.

3. Basic Methods in Microscopy, Protocols and concepts from cells: A Laboratory Manual, D. L. Spector & R. D. Goldman (Editors.), Cold Spring Harbor Laboratory Press, 2006

4. R.J. Simpson, Proteins and Proteomics: A Laboratory Manual, CSHL press, 2003

Evaluation & Grading

Evaluation will be based on assignments, lab exercises, quiz and end semester examinations. Grading from AS to DD and F, as per standard grading system followed by institute.

BT 305

Computational Biology

L T P C

2 0 2 6

Semester 6, JAN- MAY

Lectures: 28, Lab Sessions: 14

Description/Preamble

This course is designed to introduce the basic concepts and methods employed in computational biology through hands on learning experiences. Topics include protein structure prediction, Monte Carlo and molecular dynamics simulations, principles of drug design etc. with clear emphasis on the understanding and utilization of concepts and algorithms. The objective is to help the students rapidly reach the frontier of computational biology and use standard tools to solve problems in discovery research.

Industrial Relevance

Global healthcare is a trillion dollar industry. However, cost of developing a new drug from concept to market is projected to be around 35000 crore rupees (5 billion US dollars) with a success rate in clinical phase approval remain at a mere 12 %. Such 'drug failures' are key contributors to development costs. Computational methodologies have therefore become a crucial component for many drug discovery programs, especially in the early stages of the pipeline to minimize this exorbitant cost and verify transition probabilities from phase to phase using in silico prediction tools.

Undergraduate students in IIT are good in their quantitative skills and engineering practices. A good training in computational methods can make them more employable and complement current industry strategy aimed at accelerating and economizing discovery and development process. India already has a matured information technology platform in place, which can potentially supplement computational drug discovery initiatives, but not exploited effectively till date. Development of new solutions demand trained personnel who have a good understanding of the operational principles in biology along with computer aided design to effectively supplement industrial research.

Objective

To provide a broad understanding of computational techniques and resources available to biological scientists. Student should be able to supplement their future research on both experimental and computational projects with this training.

Pre-requisites

This course is designed for advanced undergraduates with reasonably strong backgrounds in molecular biology, mathematics, and computer science, but not necessarily all.

Syllabus

Analysis of protein content and organization; Analysis of protein structures, comparative modeling, structure prediction algorithms and tools, threading Empirical force field models; Bond stretching, angle bending and torsional terms, the harmonic oscillator model for molecules. Non-bonded interactions; Van der Waals, electrostatic and hydrogen bonding, united atom force fields and reduced representations, Force field parameterization. Potential Energy Surface; Convergence Criteria, Optimization; multivariable optimization algorithms, minimization methods, steepest descent and conjugate gradient methods

Molecular Dynamics Simulations; Newtonian dynamics; Integrators - Leapfrog and Verlet algorithms, truncated and shifted-force potentials. Implicit and explicit solvation models, periodic boundary conditions. Temperature and pressure control in molecular dynamics simulations. Conformational Analysis; Evolutionary algorithms and simulated annealing, clustering and pattern recognition techniques.

Monte Carlo Simulation methods; Theoretical aspects and implementation to the Metropolis method, configurationally biased Monte Carlo simulations. Methods in Drug design; Chemical databases, 2D and 3D database search, Similarity Search, Scaffold hoping, Lead identification, optimization and validation, Docking, De Novo Drug Design, Virtual screening. Quantitative Structure Activity Relationship; Introduction to QSAR, Descriptors QSARs, Regression Analysis and Partial Least Squares Analysis, Combinatorial Libraries.

Text Books

1. Leach, Andrew R. Molecular Modeling Principles and Applications (2nd Ed.). Prentice Hall USA, 2001

2. Schlick, Tamar. Molecular Modeling and Simulation - An interdisciplinary Guide. Springer verlag, 2000.

3. Donald, Bruce R. Algorithms in Structural Molecular Biology. Massachusetts Institute of Technology Press, 2011.

References

1. Hinchliffe, Alan. Molecular Modeling for Beginners, (2nd Ed.). John Wiley & Sons Ltd, 2008.

2. Bourne, Philip E. Structural Bioinformtics. (2nd Ed.). Wiley, 2009.

3. Mount, David W. Bioinformatics: Sequence and Genome Analysis (2nd Ed.). CSH press, 2005

4. Kochan, Stephen G; Wood, Patrick. UNIX shell programming (3rd Ed.). SAMS, 2003.

5. Bultinck, Patrick. Computational medicinal chemistry for drug discovery. Marcel Dekker Inc. 2004

Evaluation & Grading

Evaluation will be based on assignments, lab exercises and small projects along with mid semester and end semester examinations. Grading from AS to DD and F, as per standard grading system followed by institute.

BT 306

Bioseparation Engineering

L T P C

3 0 2 8

Semester 6, JAN- MAY

Lectures: 42, Lab Sessions: 14

Description/Preamble

This course covers the fundamental principles and the state of the art in downstream processing of bioproducts, biopharmaceuticals and recombinant products. Specialized unit operations typically involved in the separation and purification of biologics generated through fermentation and cell culture will be discussed. The course will cover techniques relevant to solid-liquid separation, product release, concentration and purification, with a focus on the total integrated process. Case studies will be discussed to illustrate the challenges and solutions in the recovery of bioproducts. In order to provide a hands-on approach, the course also includes a laboratory component, where students would conduct experiments that reinforce the fundamental principles and process parameters of downstream processing.

Industrial Relevance

Life-saving therapeutic proteins and other biologics generated through fermentation and cell culture constitute the cornerstone of a trillion dollar biopharmaceutical industry. In addition, we are witnessing a rapid growth of the bioprocess industry for production of enzymes, biochemicals, diagnostics and foods. However, the cost intensive downstream processing for product isolation and purification is a major bottleneck in leveraging the potential of a biological manufacturing process. Hence, there is a critical need to acquire a nuanced understanding of the key process and performance parameters for each unit operation involved in bioseparation, and its scale-up implications. This course will focus on issues pertaining to selection of appropriate unit operations, scale-up and design of processing units meant for biopharmaceutical manufacturing on an industrial scale. It is envisaged that the course will impart adequate training to undergraduate students and strengthen their skills in quantitative and engineering aspects of bioseparation, which will stand in good stead in pursuing a career in the biochemical and biopharmaceutical industry.

Objective

To provide a nuanced understanding and a quantitative insight of the theoretical and operational principles that govern downstream unit operations and how these operations are leveraged at a production scale. The complementary laboratory exercise will provide a hands-on approach towards providing a better conceptual understanding of separation processes for biological molecules. The course is designed to prepare undergraduate students for graduate studies in bioprocess engineering and for a career in the biopharmaceutical and bioprocess industry.

Pre-requisites

This course is designed for advanced undergraduates. A strong foundation in microbiology, biochemistry, molecular biology, basic concepts of equilibrium and kinetics, transport phenomenon, mass and heat transfer, biochemical engineering and process engineering is recommended for a better understanding of the subject.

Syllabus

Overview: Broad Categories of Bioproducts, Essential Stages in Downstream Processing, Basic Unit Operations in Downstream Processing

Solid-Liquid Separation**:** Sedimentation- principles, methods and coefficients, Centrifugation - principles, settling velocity, sigma analysis, flow rate analysis in tubular bowl centrifuge and disc centrifuge, Filtration - principles, filter aids, filtration equipment, Darcy's law, filtration rates with incompressible and compressible cakes, scale-up parameter estimations, Cell Disruption - elements of cell structure, osmotic and chemical cell lysis, extent of cell disruption, processing time and rate constant in high-pressure homogenizers and bead mills, Flocculation - electric double layer, Debye radius, critical flocculation concentration of electrolytes.

Product Isolation**:** Extraction - phase separation and partitioning equilibria, batch and countercurrent stage estimations, scale-up and design of extractors, Adsorption - common adsorbents, adsorption isotherms, process calculations in batch, continuous stirred tank and fixed bed adsorption, Membrane-based separation - membrane properties, estimation of flux and concentration polarization, membrane filtration equipment, operations, configurations and process calculations

Product Purification**:** Chromatography- principles, types, plate theory, estimation of separation parameters and column efficiency, van Deemter equation, scale-up operations and parameter estimations, Precipitation - Factors effecting protein solubility, methods of precipitation, Cohn's equation, estimation of factors effecting precipitation, Design of precipitation system

Product Polishing**:** Crystallization - principles, nucleation, growth and kinetics, analysis of batch crystallization, crystallization scale-up, design and parameter estimation, Drying - principles, vacuum-shelf and rotary dryers, freeze dryers, spray dryers, scale-up, design and parameter estimations of drying systems

Case Studies: Illustrative examples pertaining to unit operations associated with downstream processing of bioproducts biopharmaceuticals and recombinant products

Text Books

1. Belter, P. A.; Cussler, E. L.; Hu, W. S. Bioseparations: Downstream Processing for Biotechnology.John Wiley & Sons, Inc., 1988.

2. Ladisch, M. R. Bioseparations Engineering: Principles, Practice, and Economics. John Wiley & Sons, Inc., 2001.

3. Harrison, R. G.; Todd, P.; Rudge, S. R.; Petrides, D. P. Bioseparations Science and Engineering. Oxford University Press, 2003.

References

1. Doran, P. M. Bioprocess Engineering Principles, (2nd Ed.).Elsevier Ltd, 2013.

2. Shuler, M. L.; Kargi, F. Bioprocess Engineering: Basic Concepts, (2nd Ed.), Prentice Hall, 2002.

Evaluation & Grading

Evaluation will be based on quiz, assignments, laboratory exercises along with mid semester and end semester examinations. Grading from AS to DD and F, as per standard grading system followed by institute.

BT 307

Biological Data Analysis

L T P C
2 0 2 6
Semester 6, JAN-MAY
Lectures: 28, Lab Sessions: 14

Description/Preamble

This course is designed to introduce undergraduate students to different aspects of analysis of experimental data in biology. It covers two broad aspects- data visualization and statistical tools for data analysis. The basic mathematical concepts required to understand the statistical techniques are also included in this course. High throughput experiments are becoming commonplace in biology. Therefore, this course also includes commonly used tools for such large data. Biologists use a diverse array of statistical and visualization tools. This course focuses only on the introductory mathematical concepts and most widely used tools.

Industrial Relevance:

Analysis of data is a day-to-day requirement for all sorts of bioscience related industry and academics. Systematic design of experiments and analysis of data generated through those experiments, have a long history of use in agriculture, food processing and biochemical industry. Bio-pharma industry and healthcare organizations regularly use different statistical tools to understand biological pheromone, development, and spread of diseases. Like any other filed of science and technology, every field of biosciences and bioengineering, requires systematic analysis and visualization of data. These tools of visualization and analysis are generic in nature. Therefore, a student trained in these would also be able to use those tools in other fields of study.

Objectives:

To learn commonly used visualization and statistical tools for analysis of different types of data in Biology, along with the basic mathematical concepts behind such analyses.

Pre-requisites:

None

Syllabus:

Data, descriptive statistics, and visualization: Introduction to different types of data in biology; Descriptive statistics like mean, median, mode, quartiles, standard deviation, standard error; Different types of plots like scatter plot, bar graph, line graph, pie chart, box plot, frequency histogram; Understanding error bars.
Probability and probability distributions: Basic concepts of probability, conditional probability, Bayes theorem; Binomial, multinomial, Poisson, exponential, and Gaussian distribution; Sampling distribution and central limit theorem. Hypothesis testing:

Student's t-test, Z-test, Chi-squared test, ANOVA. Correlation, regression and estimation: Pearson correlation; Regression: linear, non-linear, single and multivariate; concept of likelihood and method of maximum likelihood.
Tools for data of high throughput experiments: Principle Component analysis; Clustering of data: K-means algorithm, Hierarchical clustering; Visualization tools: heatmap, volcano plot.
Laboratory component: R and MS Excel based exercises on graphical visualization of data, different tests of hypothesis, estimation of correlation, regression, PCA, clustering.

Text Books:

1. Ross, Sheldon. A First Course in Probability (9th edition). Pearson Education India, 2014.

2. Elston, Robert C.; Johnson, William D. Basic Biostatistics for Geneticists and Epidemiologists: a Practical Approach (1st edition). Wiley, 2008.

3. Hartvigsen, Gregg. A Primer in Biological Data Analysis and Visualization Using R, (1st Edition). Columbia University Press, 2014

Reference Books:

1. Whitlock, Michael C.; Schluter, Dolph. The Analysis of Biological Data (2nd edition). Freeman, W. H. & Company, 2014.

2. Quinn, Gerry P.; Keough, Michael J. Experimental Design and Data Analysis for Biologists (1st edition), Cambridge University Press, 2002.

2. Ugarte, Maria D.; Militino, Ana F.; Arnholt, Alan T. Probability and statistics with R (2nd edition). CRC press, 2016.

Evaluation & Grading:

Evaluation will be based on lab exercises, quizzes, along with mid semester and end semester examinations. Grading from AS to DD and F, as per standard grading system followed by institute.

BT 308

Bioengineering

L T P C

3 0 0 6

Semester 6, JAN-MAY

Lectures 40-42

Description/Preamble

Bioengineering may be described as the application of engineering principles to biological systems. It may further be described as a way to create a fusion of engineering and the life sciences that promotes scientific discovery and the invention of new technologies and therapies through research and education. Taking it forward, through this course it is intended to impart knowledge to students on the selected frontier areas of bioengineering which includes biosensors, regenerative medicine, biomaterials and their applications in healthcare. Biosensors section would include point of care technologies while regenerative medicine would look into concepts of tissue engineering, bioartificial organs, drug delivery with emphasis on biomaterials.

Industrial Relevance

As the global healthcare market is expanding exponentially, there is an enormous potential for related healthcare, diagnostics, medical devices subjects both industrially and in academia.

Bioengineering have a high industrial relevance towards creating direct job opportunities in various associated healthcare, diagnostics sectors. This course is specifically designed to give students an in depth insight of this exciting field and prepare them for the high on demand healthcare/bioengineering job/research market.

Objective

To provide a broad understanding about point of care diagnostics (biosensors) and regenerative medicine available to biological scientists. Students should be able to supplement their future job/research endeavors with this training.

Pre-requisites

This course is designed for undergraduates with reasonably strong background in biology.

Syllabus

Introduction; General configuration of biosensor; Types of biosensors; Basic principle and instrumentation of different types of biosensors: electrochemical, optical, piezoelectric, magnetic and calorimetric biosensors; Advance materials and techniques for developing biosensors, diagnostics and therapeutics; Recent advances in bio-based sensors and diagnostics.

Introduction; Principles of regenerative medicine; Tissue engineering approaches, its need and current available technologies; Biomaterials in tissue engineering, biomaterial properties, biodegradability and compatibility; 3D scaffold processing techniques; Stem cells, primary cells and cell lines, their culturing and differentiation; Cell-material interactions; Bioreactors in tissue regeneration; 3D in vitro disease models; Drug delivery, drug delivery formats; Recent applications in regenerative medicine.

Text Books

1. Biosensors and modern bio-specific analytical techniques, L. Gorton (ed) Volume XLIV Elsevier 2005

2. Advances in biosensors, B. D. Malhotra & A. P. F. Turner (eds), Volume 5, Elsevier science 2003

3. The Principles of Tissue Engineering (4th edition), by Robert Lanza, Robert Langer, and Joseph P. Vacanti. Academic Press (AP). 2013

4. Essentials of Stem Cell Biology (3rd edition), by Robert Lanza and Anthony Atala. Academic Press (AP). 2013

5. Biomaterials Science: An Introduction to Materials and Medicine (3rd edition), by Buddy D. Ratner, Allan S. Hoffman, Frederick J. Schoen and Jack E. Lemons. Academic Press (AP). 2012

6. Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications (6th edition), by R. Ian Freshney. Wiley-Blackwell. 2010

Reference Books

1. Journal articles.

2. Biomaterials: Principles and Applications, by J.B. Park and J.D. Bronzino. CRC Press. 2002

3. An Introduction to Tissue-Biomaterial Interactions by K.C. Dee, D.A. Puleo and R. Bizios. Wiley 2002

Evaluation & Grading

Evaluation will be based on marks scored during written exam in the quizzes, mid semester and end semester examinations. Grading from AS to DD and F, as per standard grading system followed by institute.

BT 403

Human Biology and Diseases

L T P C

3 0 0 6

Elective

Lectures: 40-42

Description/Preamble

This course is designed to give basic understanding of human body structure and function to engineering students with specialist interest in biomedical areas. In addition to basic anatomy and physiology, students will be introduced to preliminary concepts in pathology of common diseases and present and state of the art therapeutic aims and advancements. The main focus of the course will be on making the students understand the human body and diseases which will stimulate them to think and develop engineering solutions for medical problems.

Industrial Relevance

Understanding of basic human anatomy, physiology and major diseases is essential for building one's career in any of biomedical/bioengineering fields. This course will not only be helpful in students' future research work but also enhance their employability in many technological companies like Philips, Siemens etc. who are increasingly concentrating on biomedical sciences.

Objective

On completion of this course, students should be able to: Describe/identify/name anatomical positions of organs and systems and also understand basic human tissue structural architecture. Describe primary concepts in functional aspects corresponding to structure of different organ systems Understand basic pathogenesis and therapeutic aims of common diseases.

Pre-requisites

Preferably None

Syllabus

Introduction to Medical Sciences: Bio-medical nomenclature; Homeostasis and chemistry of life; Cells, tissues and organs; Introduction to gross anatomy; Histology of blood vessels, bone and muscle; Blood, Circulation and Respiration: Biochemistry of blood; Heart structure function, Arteries and veins, lymphatics; Lungs and respiration Nutrition, Digestion and Excretion:Essential Nutrients and deficiencies; Digestive system and Digestion, Kidneys and excretion Communication and Homeostasis:Bones, joints and movements; Communication systems of the body including endocrine and nervous systems; Bio-electric signals; Blood Pressure, temperature and acid-base regulation. Pathology of common diseases: Pathological basis of diseases; Obesity and complications; Diabetes and complications; Bone andjoint diseases; Cancer patho-physiology; Latest advances in treatment of hypertension, heart attack, stroke, diabetes, arthritis and cancer.

Text Books

1. Daniel D. Chiras, Human Biology, 7th Edition, Jones &Bartlett Pub, 2010.

2.W. Mark Saltzman, Biomedical Engineering: BridgingMedicine and Technology, Cambridge University Press, 2009.

3.Nicholas A. Boon, Davidson's Principles and Practice of Medicine, 20th Edition, Churchill Livingstone Elsevier, 2006.

References

1.Henry Gray, Lawrence H. Bannister, Martin M. Berry, Peter L. Williams, Gray's Anatomy: The Anatomical Basis of Medicine & Surgery, 38th Edition, Churchill Livingstone, 1995.

2.Ganong, Review of Medical Physiology, 20th Edition, McGraw Hill, 2001.

3.Dennis L. Kasper, Eugene Braunwald, Stephen Hauser, Dan Longo, J. Larry Jameson, Anthony S. Fauci, Harrison's

Evaluation & Grading

Evaluation will be based on assignments and seminars along with mid semester and end semester examinations. Grading from AS to DD and F, as per standard grading system followed by institute.

BT 404

Plant Biotechnology

L T P C

3 0 0 6

Elective

Lectures: 40-42

Description/Preamble

The purpose of this course is to educate students about the fundamental concepts of plant cell system, plant transformation, genetic engineering, bioprocess technology and their related applications, thus preparing them to meet the challenges of the new and emerging areas of plant biotechnology industry.

Industrial Relevance and Objective

Student will gain strong understanding on plant based cell cultures system. This will help them to take up plant based biological research as well as placement in the relevant biotech industry. They will be able to analyse bioprocess from an economics/market point of view.

Pre-requisites:

None

Syllabus

Unit 1: Plant Tissue Culture (10 Lectures)

Plant Development; Plant culture media and growth regulators; Cellular totipotency and micropropagation: clonal propagation, organogenesis, shoot-tip and meristem culture, somatic embryogenesis; Haploid production: Androgenesis, Gynogenesis; Triploid production; Callus culture and somaclonal variation; Somatic hybridization: protoplast fusion and culture.

Unit 2: Plant Metabolic Engineering (10 Lectures)

Secondary metabolite production: plant products of industrial importance, cell suspension culture, growth kinetics and cell viability, nutrient media optimization; Scale-up studies: elicitors and precursors; Modes of culture: batch, fed-batch and continuous cultures, cell immobilization, biotransformation; Principles, design and operation of bioreactors: instrumentation, agitation, aeration system, temperature, foam control; Downstream processing: extraction, cell disruption, chromatography and purification of metabolites.

Unit 3: Plant Transformation and Genetic Engineering for trait improvement (10 Lectures)

Plant transformation: Vector design: classical/ gateway, marker genes, marker-free technology; transformation methods: Physical, chemical and biological; Transgenic plant characterization; Genome editing; Molecular markers and marker assisted breeding; Genetic engineering approaches for biotic and abiotic stress tolerance, improvement of yield and nutritional quality.

Unit 4: Plant Functional Genomics (10 Lectures)

Plant gene structure, function and regulation; Forward and reverse genetics for gene mining, Functional characterization of plant genes: overexpression and gene silencing, RNA interference, virus-induced gene silencing (VIGS) tools, Plant microRNAs and their targets; Whole genome and single cell expression profiling, transcriptomics, bioinformatics tools for plant functional genomics.

Text Books

1. Bhojwani S. S. and Dantu P. K. Plant Tissue Culture: An Introductory Text. Springer, India, 2013

2. Davey M. R. and Anthony P. Plant Cell Culture: Essential Methods (1st Edn.). John Wiley and Sons Ltd. Publishers. West Sussex, UK, 2010.

3. Grotewold E. Methods in Molecular Biology - Plant functional genomics. Humana Press, Totowa, New Jersey, USA, 2003.

4. A. Slater, N. Scott and M. Fowler, Plant Biotechnology: The genetic manipulation of plants, Oxford University Press, 2003.

References

1. Brown T.A. Gene cloning a DNA analysis - An Introduction (6th Edn.). John Wiley and Sons Ltd. Publishers. West Sussex, UK, 2010.

2. Bhojwani S. S. and Razdan M. K. Plant Tissue Culture-Theory and Practice. Elsevier, Amsterdam, 1996.

3. M. L Shuler and F. Kargi., Bioprocess Engineering, Prentice Hall Inc., 2002.

4. Doran P.M. Bioprocess Engineering and Principles (2nd Edn.). Academic Press Ltd. Harcourt Brace & Company Publishers, San Diego, California, USA. 1995.

5. Selected papers from scientific journals, particularly Nature & Science.

Evaluation & Grading

Evaluation will be based on quizzes and written examinations (mid semester and end semester.) Grading from AS to DD and F, will be done as per the standard grading policy of the Institute.

BT 405

Cancer Biology & Therapeutics

L T P C

3 0 0 6

Elective

Lectures: 38-42

Description/Preamble

Despite the worldwide "war against cancer" that is being waged for the last five decades, a complete cure for this dreadful disease has remained elusive. Advances in treatment regimens and surgical interventions have undoubtedly helped better management of the disease. But, the field of cancer therapy faces grand challenges, such as chemoresistance, cancer heterogeneity, standardization of treatment, and early diagnosis. Today, cancer biology is a multidisciplinary area of research, in which, there is much scope for researchers in almost all science and engineering disciplines.

Industrial Relevance

Access and affordability are indispensable aspects of high-quality and high-value cancer care. Amid the diagnostic and therapeutic advancements, high cost of cancer care remains a major hurdle. India is projected to have more than 17 lakh cancer cases by the year 2020. This implies a huge burden on the economy and the social ramifications. The healthcare industry, therefore, faces a major challenge of making cancer care accessible and affordable. To overcome these challenges, smarter diagnostic methods, new cancer biomarkers, novel therapeutic drugs and smarter delivery systems are required. There is a requirement of dedicated and expert workforce with knowledge of basic and applied aspects of cancer biology that will cater to the healthcare industry.

Objective

To familiarize the students with, a) the concepts and methods in cancer biology, b) etiology and mechanisms of cancer development and progression, c) the state of the art in cancer diagnosis and therapy, and d) the challenges. The course intends to inculcate their minds with the passion for the subject that will possibly motivate them to consider a career basic and applied research in cancer biology.

Pre-requisites

Basic undergraduate courses in Biology, such as Biochemistry, Molecular Biology and cell biology, Immunology and Genetics.

Syllabus

Cell Biology- a primer: cell growth, cell death, differentiation, senescence, cell cycle, checkpoints, and associates signal transduction

Preliminary insights into cancer; transformation, carcinogenesis, classification, hallmarks of cancer, oncogenes, tumor suppressor genes, cancer microenvironment.

Mechanisms of cancer initiation and progression; mutation, clonal selection, alterations in signaling pathways, alterations in metabolism, epigenetic mechanisms, escape from immune surveillance, angiogenesis, metastasis.

Cancer Diagnosis; grading and staging, cancer biomarkers, CT, MRI, PET, microfluidics and biosensors in cancer diagnosis.

Cancer therapy; chemotherapeutic agents, immunotherapy, radiation therapy, novel anticancer drugs, chemoresistance, radioresistance, gene therapy.

Text Books

1.Devita, Hellman, and Rosenberg's Cancer: Principles & Practice of Oncology Review, Lippincott Williams and Wilkins; 3rd Revised edition edition, 2012.

2. W A Schulz, Molecular Biology of Human Cancers, Springer Netherlands; 1st edition, 2005

3. GF. Weber, Molecular Mechanisms of Cancer, Springer, 2008

4. DA Frank, Signal Transduction in Cancer (Cancer Treatment and Research), Springer; 1 edition, 2002

5. K. Mehta, ZH. Siddik, Drug Resistance in Cancer Cells; Springer; 2009

6. KE. Herold, A Rasooly. Biosensors and Molecular Technologies for Cancer Diagnostics, CRC Press, 2012.

Reference

1. Reviews and research articles from journals like Nature, Science, JAMA, Cancer research, Oncogene etc.

Evaluation & Grading

Course instructor may choose to use seminars, assignments or mini review projects as part of evaluation process. However, two quizzes, one mid-sem and one endsem examination will be mandatory. Grading will be as per IITG grading system.

BT 406

Stem Cell Biology and Engineering

L T P C

3 0 0 6

Elective

Lecture 40-42

Description/Preamble

Stem cells can be derived from multicellular organisms and hold great promise for improving human health by restoring the function of cells and organs damaged due to degeneration or injury. This course will help students to understand the role of different types of stem cells, in particular adult stem cells and pluripotent stem cells. Students will also gain understanding in characterization of these stem cells and various mechanisms involved to maintain their identity and function, and the enormous biomedical potential of these cells in drug screening, disease modeling, regenerative medicine and understanding human developmental biology.

Industrial Relevance

Pharmaceutical companies spend several million dollars before a new drug enters into market for clinical trials in humans. Human stem cell-based approaches provide an immense opportunity to screen compounds at an early stage of drug development in a human setting and thus to avoid late and costly drop-outs. The ability to generate virtually unlimited number of patient-specific stem cells and their differentiated derivatives makes them an ideal tool for screening pharmaceutical compounds using high-throughput and high content screenings, and subsequently identify novel therapeutic drugs for a particular disease of interest. Therefore, instead of using animal models, pre-testing of drug toxicity on differentiated cells from disease-specific stem cells could offer vital screening step during drug development. This will help us remove drugs with toxic side effects detrimental to health of patients and also save expenses on drugs that are withdrawn from market at a late phase. India has a rapidly booming pharmaceutical industry. Pharmaceutical drug screening using stem cells require trained personnel with good understanding of stem cells. This course is designed to provide students with an in-depth insight about stem cells and their promising therapeutic applications and prepare them to pursue research in academia and industry addressing global health concerns.

Objective

To provide a broad understanding of different types of stem cells in terms of their molecular, cellular, and potential biomedical applications. Students should be able to supplement their future job/research endeavors with this knowledge.

Pre-requisites

This course is designed for undergraduates with reasonably strong background in biology.

Syllabus

Introduction and characterization of stem cells**:** Embryogenesis; Stem cells and its historical perspective; Types of stem cells; Special characteristics of stem cells; Derivation and culture of stem cells; Various *in vitro* and *in vivo* approaches to characterize stem cells.

Mechanisms regulating stem cell characteristics**:** Extra- (role of growth factors) and intra-cellular (role of transcription factors) signaling pathways, epigenetic mechanisms and microRNAs governing stem cell characteristics.

Cell Reprogramming: iPS technology; Cell reprogramming approaches; Mechanisms of cell reprogramming; Molecular roadblocks to cell reprogramming; *In vivo* cell reprogramming.

Biomedical applications of stem cells: Stem cell applications in understanding human developmental biology, high throughput drug screening and discovery, disease modeling and regenerative medicine; Genetically engineered stem cells; Current stem cell based clinical trials.

Text Books

1. R. Burgess. Stem Cells: A Short Course. Wiley-Blackwell. 2016.

2. R. Lanza and A. Atala. Essentials of Stem Cell Biology (3rd Ed.). Academic Press.2013

3. A. Bongso and EH Lee. Stem Cells: From Bench to Bedside. World Scientific Publishing Company, 2010

References

1. F. Calegari and C. Waskow. Stem Cells: From Basic Research to Therapy, Vol 1: Basic Stem Cell Biology, Tissue Formation during Development, and Model Organisms. CRC Press.2014.

2. P. Knoepfler. Stem Cells: An Insider's Guide. World Scientific Publishing Company. 2013.

3. D. Warburton. Stem Cells, Tissue Engineering and Regenerative Medicine. World Scientific Publishing Company.2015.

4. A.A. Vertes, N. Qureshi, A.I. Caplan, L. Babiss. Stem Cells in Regenerative Medicine: Science, Regulation and Business Strategies. Wiley-Blackwell.2015.

Evaluation & Grading

Evaluation will be based on quizzes, along with mid-semester and end-semester examinations. Grading from AS to DD and F, as per standard grading system followed by institute.

BT 407

General Virology

L T P C

3 0 0 6

Elective

Lectures: 40-42

Introduction

The general virology course has been designed to bring in the general aspects of the virology. It contains the virus history and its diversity of its infection strategy from lower kingdom to higher kingdom's individual. It has been illustrating about the consequences of virus infection, classification and nomenclature procedure. It also contains the antiviral state of virus infection and viral counter attack mechanism. Further, it summarizes the characteristics of different viruses on the basis of nucleic acid genome type. Nearly, all the chapters have been updated in advanced reflection of last 5 years research and scientific study with classical stone. The aim of this course to develop the understandable concept and ideas for new advanced research for beneficiary of human kind and academic field in front of student.

Academic and research relevance:

Last year, Ebola had reemerged in West Africa, causing death of thousands of lives and affecting many more. Middle East respiratory syndrome (MERS) has been continuing to be reported, with a severe acute respiratory syndrome (SARS) ever present. Chikungunya virus has been spreading to the Western Hemisphere and epidemic in southern United States and Caribbean land. We are staying in a world with hundreds of millions of people infected with hepatitis B and C viruses chronically. Since last decades the discover its antiviral drug but millions remain infected. Viruses has been accounted for up to 20% of all human cancers, in some cases vaccines are able prevent the disease but not in every cases. We never know when the next strain of influenza will arise. All these problems and enigma regarding its diagnostic, prevention and cure can be successfully achieve after knowing all the unknown facts about the virus. There might be an argument that preventing and treating of these diseases can possible only after interfering of a vigorous research enterprise and also from good developed idea of human brain.

Objective

The objective of Virology course is to describe the replication strategies of RNA and DNA viruses and its effects on cell growth control, animal and human after infection. After completing of the course learner should be able to: illustrate basic principles of virus classification, viral structure and its replication and also able in describing the basic of virus - host interactions that lead to pathogenesis and cure of some crucial viral disease.

Pre-requisites

Basic knowledge of molecular biology of DNA, RNA and protein help to understand all these things very easily.

Syllabus

Introduction

Virus, its history, diversity, shapes and sizes.

Genome Organization:

Type of genome, components of genome and its use for virus and research.

Isolation and purification of virus and its component.

How can we isolate different types of viruses, different purification method of virus and its structural component.

Consequences of virus infection to animals and human.

How viruses cause disease and effect of viral infection on host macromolecules, establishment of the antiviral state and counter attack mechanisms.

Classification of viruses and nomenclature.

Virus nomenclature procedure and classification method.

Description about general mode of replication using Baltimore classification

I: dsDNA viruses

II: ssDNA viruses

III: dsRNA viruses

IV: (+)ssRNA viruses

V: (-)ssRNA viruses

VI: ssRNA-RT viruses

VII: dsDNA-RT viruses

Bacteriophage and some plant viruses.

Description about some plant viruses and their economic importance.

Description about some dsDNA virus: Adenoviruses, herpes viruses, poxviruses

Description about some ssDNA virus: Parvoviruses, circoviruses

Description about some dsRNA strand virus: Reoviruses.

Description about some +ve strand RNA viruses

Picornaviruses, Flaviviruses- West Nile virus and Dengue virus. Summarization of Coronaviruses- SARS pathogenesis.

Description about some -ve strand RNA viruses

Paramyxoviruses, Orthomyxoviruses: Influenza pathogenesis and Bird flu. Rhabdoviruses: Rabies pathogenesis.

Description about some ssRNA-RT viruses: Retroviruses: structure, classification, life cycle; reverse transcription. Retroviruses: HIV, viral pathogenesis and AIDS.

Description about some dsDNA-RT viruses: Hepatitis B virus.

Description about some miscellaneous viruses:

Emerging viruses such as Ebola, Zika, MERS etc.

Text Books

1. Principles of Virology 2nd edition by S.J. Flint, L.W. Enquist, R.M. Krug, V.R. Racaniello, and A.M. Skalka.

2. Fenner's Veterinary virology, 4th edition

by N. James MacLachlan and Edward J. Dubovi.

3. Medical Virology 4th edition by David O.White and Frank J. Fenner.

4. Genomes 3 by T. A. Brown

Reference

1. Fields Virology 5th Edition by Bernard Fields, David Knipe and Peter Howley.

Evaluation & Grading

Assignments, preferable projects and mid and end semester examinations performance are evaluation and grading criteria. Grading system from AS to DD will give as per institute rule.

BT 408

Structural Biology

L T P C

3 0 0 6

Elective

Lectures: 40-42

Description/Preamble

This course is for students (B.Tech./M.Tech./Ph.D) who want to understand the basic theory and practical aspects of techniques used for determination of three-dimensional structure of proteins. The course will focus on descriptions of methods used to study structure and dynamics of macromolecules, and their application to various biological systems including soluble and membrane-bound proteins, DNA/RNA, and protein-nucleic acid complexes.

Pre-requisites

This course is designed for students who wish to understand the mechanisms of biological processes and structure-based drug development using structures of proteins, thus students need to have basic knowledge of proteins.

Syllabus

Introduction: introduction to structural biology, structure-dynamics-function relationships; Overview of recombinant protein production: molecular cloning, over expression and protein purification of recombinant proteins; Introduction to biological macromolecular crystallography: crystallization techniques, X-ray scattering, X-ray intensity data collection, crystal lattice and symmetry, electron density and structure factors, phase problem, molecular replacement, isomorphous replacement methods, anomalous scattering, SAD/ MAD phasing, model building and refinement; Introduction to nuclear magnetic resonance: Nuclear spin angular momentum, magnetic moment, spin precession, Zeeman splitting, spin -½ nuclei, spin states, and energy levels; Vector model of NMR; Chemical shift, J-Coupling and spin-spin splitting; nuclear spin relaxation, Nuclear Overhauser effect, NMR instrumentation; Data acquisition and processing; roduct Operator Formalism, Multidimensional NMR and protein structure determination, glimpses of solid state NMR.

Text Books

1.T. A. Brown, Gene Cloning and DNA Analysis: an Introduction, (6th Ed), Wiley-Blackwell, 2012.

2. David Blow, Outline of Crystallography for Biologists, Oxford University Press, 2002.

3.Bernhard Rupp, Biomolecular Crystallography: Principles, Practice and Application to Structural Biology, Garland Science, 2009.

4.James Keeler, Understanding NMR

Spectroscopy, Wiley, 2nd ed., 2010

References

1. G.E. Schulz and R.H. Schirmer, Principles of Protein Structure, Springer, 1979.

2. Thomas E. Creighton, Proteins: Structure and Molecular Properties, W.H. Freeman, 1992

3.David Whitford, Proteins: Structure and Function, John Wiley, 2005

4.Levitt, M. H., Spin Dynamics: Basics of Nuclear Magnetic Resonance, 2nd ed., Wiley, 2008

Evaluation & Grading

Evaluation will be based on marks scored during written exam in the two quizzes, mid semester and end semester examinations. Grading from AS to DD and F, as per standard grading system followed by institute.

BT 409

Cell signaling and Development

L T P C

3 0 0 6

Elective

Lectures: 40

Description/Preamble

Cell signaling process is an integral part of the communication system in a biological system. Cell signaling plays a vital role in coordinating almost all biological processes such as growth, development, maintenance, disease, and defense. This course will help students in understanding complex network of various cell signaling mechanisms to explore its potential technological applications in diverse fields. This course is proposed to be floated as a departmental open elective and for its B.Tech, M.Tech and PhD students..

Industrial Relevance

This course is a basic science course; however, understanding the cell signaling in development, disease, drug screening and product development is hugely relevant to the pharmaceutical, nutraceutical, and cosmetic industries.

Objective

Understanding of the role of cell signaling in controlling biological processes using a number of model organisms.

Pre-requisites: Nil

(BTech, final year), postgraduate (MTech and PhD) students with strong backgrounds in molecular biology; however, this is not essential.

Syllabus

Introduction to cell signaling pathways and development in different model organisms; Evolutionary similarities of the cell signaling processes; Intracellular signaling pathways: G protein-coupled receptor (GPCR) signaling, protein kinases and phosphatases, second messengers; Cell -cell recognition and adhesion; Receptor -ligand interactions, coupling of receptors to different signaling machinery; Regulation of receptor function, modifications and adaptation of cells; Techniques for measuring intracellular concentrations of second messenger calcium ions, cellular roles of calcium, calcium homeostasis. Signaling and development: regulation of cell signaling, two-component system, homeotic genes, epigenetics, origin of the novelty, diseases caused by defect in signaling systems; Applications of cell signaling and developmental biotechnology in disease model, drug screening, product development.

Text Books:

1. M. J. Berridge, Cell Signaling Biology, Portland Press, ISSN: 1749-7787, 2014.

2. F. Marks, U. Klingmuller and K. Müller-

Decker, Cellular signal processing: an introduction to molecular mechanisms of signal transduction, Garland Science; 1st Edition, 2008

3. G. Krauss, Biochemistry of signal transduction and regulation, Wiley-VCH; 3rd Edition, 2003

4. B. K. Hall and W. M. Olson (Eds.), Keywords and concepts in evolutionary developmental biology, Harvard University Press; 1st Edition, 2003.

5. B. Alberts, A. Johnson, J. Lewis, M. Raff, K. Roberts and P. Walter, Molecular biology of the cell. Garland Science; 4th Edition, 2002.

References

1. R. K. Ockner, Integration of metabolism, energetics, and signal transduction, Springer; 1st Edition,2004.

2. F. H. Wilt and S. C. Hake, Principles of developmental biology, W. W. Norton & Co.; 1st Edition, 2004

3. T. Finkel and J. S. Gutkind (Eds.), Signal transduction and human disease, Wiley-Interscience; 1st Edition, 2003

4. D. P. Kasbekar and K. McCluskey (Eds.), Neurospora: Genomics and molecular biology, Caister Academic Press; 1st Edition, 2013

5. Hoffmeister, D. (Ed.), THE MYCOTA, Biochemistry and Molecular Biology, ISBN 978-3-319-27788-2, Springer, 2016

Evaluation & Grading

Evaluation will be based on regular assignments, class test, mid semester, and end semester examinations. Grading will be done as per standard grading system of the institute.

BT 410

Proteomics: Methods and Applications

L T P C

3 0 0 6

Elective

Lectures: 42

Description/Preamble

This course aims to provide the detailed guidelines and procedures to characterize protein in a complex biological sample. It involves basic information about protein and experiments to separate the complex biological mixture and then identify the protein of interest. The objective is to introduce the utility of proteomics and its potentials to understand complex biological phenomenon and problems in biotechnology industry.

Industrial Relevance

Protein plays multiple roles in biological process. it regulates cellular processes, used for repair and growth process of an organism. As a result it is a attractive product for biotechnology and pharma industry. The production of protein in industrial setting for therapeutic purpose is linked with characterization and quality assessment. In addition, bio-pharma industries very heavily invest on modifying proteins with enhanced activity or identifying crucial factors responsible for a particular patho-physiological condition.

A good learning of proteomics approaches and related experimental details will help the student to meet the industrial demand looking for well-trained personnel.

Objective

The objective of the current course is to provide broad understanding of proteomics approaches used to solve complex biological problems. It may help student to utilize this knowledge for their future research problems, both for their B.Tech project as well as for future research in Ph.D.

Pre-requisites

This course is designed for advanced undergraduates with reasonably strong backgrounds in biochemistry, biophysics, molecular biology and bioinformatics, but not necessarily all.

Syllabus

Protein: Introduction, structure, functional diversity, modification, analytical tools to identify protein modifications; Protein Separation

Techniques: Basic principle of chromatography, instrumentation, ion-exchange, size-exclusion and affinity chromatography techniques; Analysis of protein sample: Basic principle of electrophoresis, instrumentation, SDS-PAGE, Native PAGE, Preparative PAGE, different PAGE staining methods; Isoelectric focusing (IEF): Basic Principle of separation, Method of Isoelectric focusing of complex biological sample, 2-D gel electrophoresis and its different variants, Image analysis of 2-D gels; Mass Spectrometry: Basic principle, Instrumentation, Method of preparing sample for Mass spectrometry, LC-MS and its potential in proteomics. Strategies for protein identification: Discussion about different types of analytical tools, blotting techniques, protein sequencing, peptide mass fingerprinting, Proteome database etc.; Potentials of proteomics in biotechnology : Few Real basic problems to highlight Clinical and biomedical application of proteomics; different research articles related to cancer biology, cell biology, plant biotechnology, down-stream processing, immunology and drug discovery etc. can be chosen for this purpose. Research articles related to cancer biology, cell biology, plant biotechnology, down-stream processing, immunology and drug discovery etc. can be chosen for this purpose.

Text Books/ References

1. R.M.Twyman, Principles of Proteomics, BIOS Scientific Publishers, 2004.

2. P.Michael Conn, Handbook of Proteomic Method. Humana Press, Totowa, New Jersay, USA, 2003.

3. Stryer, Biochemistry, W. H. Freeman and Co., New York, 2007.

4. R. D. Appel and D.F. Hochstrasser, Proteome Research: New Frontiers in Functional Genomics, Springer, 1997.

5. C. Branden and J. Tooze, Introduction to protein structure, Garland Publishing, 1998.

6. Selected review papers from different journals

Evaluation & Grading

Evaluation will be based on assignments, lab exercises, quiz and end semester examinations. Grading from AS to DD and F, as per standard grading system followed by institute.

BT 410 Proteomics: Methods and Applications

BT 411

Metagenomics

L T P C

3 0 0 6

Elective

Lectures: 42

Description/Preamble

The unfathomable microbial number makes it difficult to study them. Metagenomics is the genome analysis of a community of microbes that can be harnessed to access the untapped diversity and biotechnological potential of the microbial world in a non-culturable way. Recent developments like high-throughput sequencing technologies and bioinformatics tools to process and interpret data is impacting the fields of genomics and metagenomics and has opened up new possibilities of global analysis of biological systems and the ecological role of microbial Communities. Apart from introducing the students to the basic concepts this course would introduce students with the recent advances in theoretical, methodological and applied areas of metagenomics.

Syllabus

The microbial world-statistics and variations; Introduction: genomics to metagenomics; Different metagenomic milieu; Viral,bacterial, fungal, algal and protozoan metagenomics; Basic methods and techniques for metagenomics study: sequencing technology, gene-expression systems, single-cell analyses; Analysis of metagenomics data: metagenomics analysis servers, metadata, preprocessing, identifying genes, annotations; Comparative metagenomics; Ecological metagenomics; Metabolic reconstructions and models; Applications of metagenomics: metagenomics of the human microbiome, bio-prospecting novel genes, metagenomics for industrial bioproducts, metagenomics for bioremediation, plant-microbe interactions, metagenomics and ecosystems biology; Major stakeholders in metagenomics; Metagenomics and the convention on biological diversity; Biosafety and IPR issues in metagenomics.

Text/References

1. D. Marco (Ed.), Metagenomics: Theory, Methods and Applications,1st Edn., Caister Academic Press, 2010.

2. W. R. Streit and R. Daniel (Eds.), Metagenomics: Methods and Protocols, 1st Edn., Humana Press, 2010.

3. K. E. Nelson (Ed.), Metagenomics of the Human Body, 1st Edn., Springer, 2010.

4. D. Marco (Ed.), Metagenomics: Current Innovations and Future Trends,1st Edn., Caister Academic Press, 2011

BT 412

Enzymology

L T P C

3 0 0 6

Elective

Lectures: 42

Description/Preamble

Enzymology is a branch of biology which deals with chemistry, biochemistry and effects of enzymes, their kinetics, structure and function as well as their relation with each other. Enzymes are mostly proteins which catalyze specific metabolic reactions and are synthesized in cells for addressing different functions.

Industrial Relevance

The field of enzymology and enzyme has been studied since centuries in many industrial processes like tannery, brewing, bakery, dairy, etc. Today, enzymes are considered to be the core of the basic biotechnology techniques such recombinant DNA technology, the target of therapeutics drugs and all biotechnological processes. Moreover, they are used in analytical procedures, in human and animal therapies and in industrial processes.

Objective

To provide a broad understanding of enzyme kinetics, structures, function and as well their relation with each other. The various applications of enzymes in industrial processes will also be addressed.

Pre-requisites

This course is designed as elective for M.Tech and PhD students of Department of Biosciences and Bioengineering. The course is also open for final year B.Tech students of the Department.

Syllabus

Basic concepts of enzyme: introduction and chemical nature of enzymes, naming and classification of enzymes, specificity of enzyme action, monomeric and oligomeric enzymes, chemical nature of enzyme catalysis; Enzyme kinetics: derivation of Michaelis-Menten equation for single substrate enzyme and concept of Km and Vmax, and Enzyme turnover number (Kcat), kinetics of zero & first order reactions, type of inhibitors and their effects on the enzyme catalyzed reaction, Exposure to multi substrate enzymes catalyzed reactions; Enzyme Regulation: General mechanisms of enzyme regulation, sigmoidal and allosteric enzymes, Hill and Scatchard plots, positive and negative co-operativity with suitable examples (like aspartate transcarbamoylase & phosphofructokinase); Applied Enzymology: Applications of enzymology; structure and function of enzymes; Enzyme engineering with suitable examples.

Text Books

1. Irwin H. Segel, Biochemical Calculations: How to Solve Mathematical Problems in General Biochemistry 2nd Ed., Wiley India Pvt. Ltd, 2010.

2. T. Palmer (Ed), Enzymes: Biochemistry, Biotechnology, Clinical Chemistry, 2nd Ed., Horwood Publishing Chinchester, 2007 .

3. J. L. Tymoczko, J. M. Berg and L. Stryer, Biochemistry, 8th Ed., W. H. Freeman, 2015.

References

1. Selected articles from journals like Journal of Biological Chemistry, Enzymes and Microbial Technology, Molecular Catalysis, Enzymology etc. and review articles appeared in journals, books and series.

Evaluation & Grading

Evaluation will be based on assignments, quizzes, final and mid semester examination. The assignment will be done as per existing norms of the institute.

BT 413

Metabolic Engineering

L T P C

3 0 0 6

Elective

Lectures: 40

Description/Preamble

The objective of the course is to identify the specific metabolic pathways for genetics manipulations of a living cell that result in improvements in yield and productivities of biotechnological processes. Topic covered include; application of metabolic engineering, pathway regulation and different metabolic tools such as constrained based flux analysis, isotopic flux analysis, metabolic control analysis to identify the specific target for manipulation of the metabolic pathway.

Industrial Relevance

Even after bioprocess optimization cell may not produces the desired product such as chemicals, fuels, materials, pharmaceuticals, and medicine with a maximum titer due to metabolic pathway flux constraint at its genetic level. This course will help to identify the rate limiting metabolic pathway using different metabolic pathways analysis tools for genetic improvement to get the maximum titer of the product.

Objective

The aim of the course is to understand the concept of mathematical modelling of metabolic processes for genetic manipulation to improve the product formation range.

Syllabus

Basic concept and successful application of metabolic engineering; Demonstrates metabolic engineering in action with numerous examples of pathway engineering for strain improvement, product overproduction, byproduct minimization, extension of substrate utilization range

Regulation of Metabolic Pathways; Basic biochemical pathways, primary and secondary metabolism, Regulation of Metabolic Pathways, Enzyme regulation, rate limiting step

Metabolic flux analysis (MFA); Models of cellular reactions, stoichiometry of cellular reactions, reaction rates, dynamic mass balances, metabolic network, MFA of exactly determined systems, over determined systems.

Constraint based metabolic flux analysis; Underdetermined systems, concept of linear programming to metabolic model, implementation of these concept to genomic scale metabolic model, Flux balance analysis (FBA), Regulatory on-off Minimization (ROOM) and Minimization of metabolic adjustments (MOMA), Elementary mode analysis, Extreme pathways.

Metabolic Fluxes by radiolabeled tracer; Determination of metabolic fluxes by isotope labeling, 13C labeling metabolic flux analysis using analytical technique, stationary and in-stationary assumption. **Metabolic Control analysis (MCA)**; control coefficients, MCA of linear and branched pathways, control of flux distribution at branch point, grouping of reactions, optimization of flux amplification.

Text Books

1. G. Stephanopoulos, A. Aristidou and J. Nielsen, Metabolic Engineering Principles and Methodologies, Academic Press, 1998.

2. Jens Nielsen (eds.), Metabolic Engineering, Advances in Biochemical Engineering/ Biotechnology, springer

References

1. Bernhard Palsson, Systems Biology: Constraint-based Reconstruction and Analysis, Cambridge University Press, 2015.

2. Y. Lee and E. T. Papoutsakis, Metabolic Engineering, Marcel Dekker, New York, 1999.

Evaluation & Grading

Evaluation will be based on assignments and hour examination like quiz in class along with mid semester and end semester examinations. Grading from AS to and F, as per standard grading system followed by institute.

BT 414

Nanobiotechnology

L T P C

3 0 0 6

Elective

Lectures: 40-42

Description/Preamble

The prime aim of this course is to provide fundamental and applied knowledge in the interface between chemistry, physics, and biology on the nanostructural level with a focus on biotechnological applications. This course will provide insights of the interdisciplinary areas of nanobiotechnology including fundamental engineering principles involved in it; apart from the inherent technological applications in various domains. This course will provide information to students about the scopes of nanobiotechnology, history of nanobiotechnology, various types of nanomaterials, bioconjugation, characterization, applications, and risks involved due to these nanomaterials.

Objective

Major objective of this course is to educate students about the fundamentals, importance, applications, and limitations of nanobiotechnology. The course may also attract students to take-up jobs and motivate them to be entrepreneurs in order to achieve commercially important research goals.

Industrial Relevance

Nanobiotechnology teaches fundamental and applied aspects of nanotechnology and biotechnology. It has tremendous scope in various industries including healthcare, agriculture, environment, and food industries. For instance, in healthcare various diagnostics kits are available in market based on nanoparticle-receptor conjugate system, in the agriculture industry, engineered nanoparticles have been serving as nanocarrier, containing herbicides, chemicals, or genes, which target particular plant tissues to release their content. In environment, nanobiotechnology is helpful in bioremediation of heavy metal ions, toxic chemicals, and xenobiotics. Overall, the course designed will provide students a comprehensive insight about and biotechnology and its applications in industry which may encourage them to pursue research in academia and industry addressing global health issues.

Pre-requisites

Fundamental knowledge of biology, chemistry, physics.

Syllabus

Module 1 [10 lectures]

History and scope of nanotechnology, present and future of nanotechnology, bio-inspired nanostructures, type of nanomaterials and their synthesis; metal nanoparticles, nanoclusters, carbon nanostructures, 2D materials; nanoporous material, nanocomposite; polymeric composite, nanobioconjugates design

Module 2 [15 Lectures]
Characterization of nanobiomaterials: principle and applications; concept of nanotuning; nanomotors; nanomachines; nanobiosensors; fabrication, types, and applications, invitro and invivo sensors, application of nanobiosensors in healthcare, food safety, environmental monitoring; lab on chip devices for sensing and detection, micro/nanofluidics.

Module 3 [10 Lectures]
Nanotoxicology; bio-distribution of nanomaterials in human body, biomarkers, analysis methods; nanomedicine; nanoparticles for therapy-drug delivery, gene delivery, protein delivery, photothermal and photodynamic therapy with case studies; nanoparticles based bioimaging; nanotheranostics, concepts and case studies.

Module 4 [5 Lectures]
Application of nanobiotechnology in various industries, commercially available products/processes based on nanobiotechnology, plant and microbe mediated nanoparticles, nanobioremediation.

Text and Reference Books

1. Nanobiotechnology: Concepts, Applications and Perspectives, edited by C.M. Niemeyer and C. A. Mirkin, 2012, Wiley-VCH Verlag GmbH & Co

2. Medical Nanotechnology and Nanomedicine, Harry F. Tibbals, 2010, CRC Press, USA.

3. Nanobiosensors for personalized and onsite biomedical diagnosis, edited by: Pranjal Chandra, 2016, IET, London, United Kingdom.

4. Nanomedicine: Principles and Perspectives, Edited by: Ge, Y., Li, S., Wang, S., Moore, R, 2014, Springer-Verlag NewYork.

5.Nanotoxicology: Materials, Methodologies, and Assessments, edited by: Durán, Nelson, Guterres, Silvia S., Alves, Oswaldo Luiz, 2014, Springer- Verlag New York.

6. Latest research / review papers will be discussed on related topic.

Evaluation & Grading

Evaluation will be based on quizzes, along with mid-semester and end-semester examinations.

BT 415

Tissue Engineering and Regenerative Medicine

L T P C

3 0 0 6

Elective

Lectures: 40-42

Description/Preamble

Human tissue and/or organ failure, as a result of disease or trauma, is a major health concern world over. Treatment options include donor based transplantation, surgical repair, artificial prostheses etc. Ultimately, however, major damage may never be repaired in a truly satisfactory way. For such cases tissue engineering/regenerative medicine has emerged as a potential alternative, whereby tissue and organ failure is addressed by implanting lab grown tissue grafts and organ mimics that are fully functional and compatible. A variety of approaches are used to engineer these tissues in combination with stem cells/biomaterial/growth factors etc. Stem cells because of their remarkable regenerative potential are a preferred choice. Notable engineered tissues include bone, cartilage, blood vessels, liver, skin, muscle, nerve conduits etc.

Industrial Relevance

As the global healthcare market is expanding exponentially, there is an enormous potential for related healthcare subjects both industrially and in academia. Tissue engineering and regenerative medicine endeavors in the past decade have come a long way both in terms of knowledge base and potential applications towards delivering healthcare solutions e.g. implants/grafts/drug delivery systems etc. They have a high industrial relevance towards creating direct job opportunities in various associated healthcare sectors. This course is specifically designed to give students an in depth insight of this exciting field and prepare them for the high on demand healthcare/bioengineering job/research market.

Objective

To provide a broad understanding of tissue engineering and regenerative medicine techniques and stem cell resources available to biological scientists. Students should be able to supplement their future job/research endeavors with this training.

Pre-requisites

This course is designed for undergraduates with reasonably strong background in biology.

Syllabus

Introduction to tissue engineering & regenerative medicine: principles underlying tissue engineering/regenerative medicine strategies, key concepts of tissue engineering/regenerative medicine, its need and current available technologies.

Structure and organization of tissues: various cell and tissue types, its organization, structure-function relationship.

Stem cells: stem cell types, their characteristics, potency

Cell isolation, culture and differentiation: primary cell isolation techniques, cell culture needs, differentiation abilities of stem cells towards specific lineages.

Biomaterials in tissue engineering & regenerative medicine: knowhow on current biomaterials, natural vs. synthetic, role of a biomaterial in tissue engineering, its properties, biodegradable polymers and 3D scaffold processing techniques;

Cell-cell and cell-matrix interactions: knowhow and importance of such interactions, extracellular matrices; tissue repair and angiogenesis

Biocompatibility and immune rejection: biomaterial/graft compatibility, host acceptance and rejection

Drug, growth factor and gene delivery: knowhow and importance of sustained and controlled delivery, implications and applications

Bioreactors in tissue engineering & regenerative medicine**:** knowhow on bioreactors, tissue growth and maturation, implications and applications.

Applications in tissue engineering & regenerative medicine: tissue regeneration case studies on bone, cartilage, blood vessel, skin, cornea etc.

Text Books

1. The Principles of Tissue Engineering (4th edition), by Robert Lanza, Robert Langer, and Joseph P. Vacanti. Academic Press (AP). 2013.

2. Essentials of Stem Cell Biology (3rd edition), by Robert Lanza and Anthony Atala. Academic Press (AP). 2013

3. Biomaterials Science: An Introduction to Materials and Medicine (3rd edition), by Buddy D. Ratner, Allan S. Hoffman, Frederick J. Schoen and Jack E. Lemons. Academic Press (AP). 2012

4. Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications (6th edition), by R. Ian Freshney. Wiley-Blackwell. 2010

References

1. Biomaterials: Principles and Applications, by .B. Park and J.D. Bronzino. CRC Press. 2002.

2. An Introduction to Tissue-Biomaterial Interactions by K.C. Dee, D.A. Puleo and R. Bizios. Wiley 2002.

Evaluation & Grading

Evaluation will be based on marks scored during written exam in the quizzes, mid semester and end semester examinations. Grading from AS to DD and F, as per standard grading system followed by institute.

BT 416

Bioenvironmental Engineering

L T P C

3 0 0 6

Elective

Lectures: 36-40

Pre-requisites

NIL

This elective course is designed for undergraduates (B.Tech) students.

Objective

The aim of this elective course is to provide students with a broad and thorough education in bioenvironmental engineering fundamentals, applications, and design so as to prepare graduates for the practice of bioenvironmental engineering at the professional level with confidence and skills necessary to meet the technical and social challenges of the future.

Course Content

Introduction; Characterization of wastewater and waste air; Biomass characterization; Biological phosphorous removal; Biological sulfate reduction; Biological nitrogen removal; Aerobic organic removal; Removal of volatile organic and inorganic compounds; Heavy metal removal by Biosorption.

Theory and design of biological unit operations: Aerobic suspended growth systems; Aerobic attached growth systems; Anaerobic suspended and attached systems; Sequential batch Reactors.

Text Books

1. Mark C.M. Van Loosdrecht, Per H.Nielsen, Carlos M. Lopez- Vazqez and Damir Brdjanovic, Experimental Methods in Wastewater Treatment, IWA Publishing, 2016

2. Metcalf and Eddy Inc, Wastewater Engineering: Treatment and Reuse, McGraw-Hill publication, 5th Edition, 2013.

3. J. S. Devinny, M. A. Deshusses and T. S. Webster, Biofiltration for Air Pollution Control, Lewis Publishers, CRC Press, 2008.

4. H. S. Peavy, D. R. Rowe and G. Tchobanoglous, Environmental Engineering, McGraw-Hill Inc., 2013.

References

1. B. Ritmann and P. L. McCarty, Environmental Biotechnology: Principle & Applications, 2nd Ed., McGraw Hill Science, 2001.

2. G. M. Evans and J. C. Furlong, Environmental Biotechnology: Theory and Applications, Wiley Publishers, 2010.

Evaluation & Grading

Evaluation and Grading will be done as per the standard grading policy of the Institute.

BT 417

Bioprocess Instrumentation and Control

L T P C

3 0 0 6

Elective

Lectures: 42

Description/Preamble

Cellular activities such as those of enzymes, DNA, RNA and other components are the primary variables which determine the performance of microbial or cellular cultures. The development of specific analytical tools for measurement of these activities in vivo is therefore of essential importance in order to achieve direct analytical access to these primary variables. This course aims to provide basic introduction to principle and operation of state of routine and state-of-art instrumentation involved in bioprocess monitoring applications. bioprocess control provides special challenges due to significant process variability and the complexity of biological systems. The basics concepts of bioprocess control and different types of control strategies are included in this course.

Objective

Present an overview of off-line, at-line and in-line sensors used in bioprocess monitoring.

Provide a fundamental understanding on basic operation and principle of sensors for bioprocess monitoring.

Demonstrate a capability to model simple dynamical systems using continuous, discrete-time, and state-space methods.

Design control systems using classical, digital, and optimal control techniques.

Pre-requisites

Students should have prior knowledge on the concepts of Biochemical Engineering.

Syllabus

Introduction:

General concepts and introduction to process instrumentation - static and dynamic characteristics - errors, standards and calibration.

In-line Instruementaiton:

Temperature-pH-DO-dissolved CO2 - exhaust gas analyzer - redox potential - dielectric spectroscopy - optical density probe-fluorescence spectroscopy - mid/NIR spectroscopy - calorimetry

At-line Instrumentation:

Sampling devices - flow injection analysis - HPLC - Electrochemical sensors - software sensors.

Off-line Instrumentation:

Flow cytometry - NMR spectroscopy - field flow fractionation - cell counter

Bioprocess Control:

Preliminary Concepts - Control theory terminology - State-space modelling of physical systems; differential equations; discrete-time equations - Laplace transforms;

transfer functions - Simulation algorithms - Classical control - Stability, eigenvalue analysis - PID control basics, Simple tuning techniques -Discrete-time Control basics - Sampling - Discrete-time transfer functions - Stability in the discrete domain.

Control strategies**:** Brief introduction to Model predictive control -adaptive control - fuzzy logic control - ANN control.

Text Books

1. George Stephanopoulos (1984), PHI Publishers, Chemical Process Control: An Introduction to Theory and Practice

2. Denis Dochain, Wiley Publishers, 1st edition, Bioprocess Control

3. M. K. Ghosh, S. Sen, S. Mukhopadhyay, 1st edition, 2008, Measurement & Instrumentation: Trends and Applications

References

1. Bailey, J. E., and D. F. Ollis. Biochemical Engineering Fundamentals. 2nd ed. New York, McGraw-Hill, 1986.

2. Pauline M. Doran. Bioprocess Engineering Principles. 2nd ed. Elsevier Science & Technology Books. 1995

Evaluation & Grading

Evaluation will be based on tutorials, quizes in class along with mid semester and end semester examination. Grading from AS to DD and F, as per standard grading system followed by Institute.

BT 418

Systems Biology

L T P C

3 0 0 6

Elective

Lectures: 42

Description/Preamble

This course is designed to introduce undergraduate students to key ideas and mathematical tools of Systems Biology. Concepts of Systems Biology have their origin in Dynamical Systems Theory and associated mathematical developments. Biologists use both traditional and high-throughput experimental techniques to explore those concepts. Mathematical modeling is used to supplement those experimental observations and to generate new testable hypotheses. The mathematical aspects of Systems Biology fall in three broad categories

- a) deterministic models, b) stochastic models for cellular and molecular processes and c) graph theory-based analysis of biological networks. This course will introduce students to all three approaches.

Industrial Relevance:

Over the last few decades' biochemistry, molecular and cellular biology has made tremendous development in understanding biological phenomena. However, it has also been observed that several biological phenomena like cell signaling, development, immune response, metabolic disorders, physiological homeostasis, cannot be fully understood by focusing only on individual molecular and cellular components.

It is now accepted that one needs to understand integration of different molecular and cellular processes, at different levels, to comprehend those phenomena. Systems Biology provides us the tools for such integrated understanding. It requires collaboration between people having skills in experimental biology, data analysis, and mathematical modeling. Biologists in academics are using mathematical concepts and tools of Systems Biology to understand questions at cellular- and organism-level. Bio-pharma industry is using those tools to understand diseases and identify newer therapeutic modalities. On the other hand, Biochemical industry is using the same tools to engineer microorganisms to improve industrial products. This course will introduce students to key mathematical concepts and common modeling tools of Systems Biology.

Objectives

To learn key concepts and common mathematical tools of Systems Biology.

Pre-requisites

Biochemistry, Molecular Biology and Genetic Engineering.

Syllabus:

Introductions to systems biology: Key concepts of systems biology- dynamic systems, network, self-organization, emergent properties, homeostasis, robustness.

Analysis of dynamical systems: Basic concepts of modeling biological systems using ordinary differential equations; Numerical methods of solving ordinary differential equations- Euler method; Graphical analysis of ordinary differential equation based models - direction field, phase plane; stability analysis of linear and non-liner systems of ordinary differential equations; Concept of Bifurcation.

Modeling molecular network: Concept of molecular network and network motifs; Mathematical formulations for elementary molecular processes - Law of Mass Action, ligand binding, enzymatic reaction, transcription, translation; Analysis of biochemical switches, positive feedback, negative feedback, transcriptional circuits; Bifurcation, and hysteresis in network motifs.

Stochasticity biochemical networks: Basic concepts of probability and random variables; Probability distributions- Binomial, Poisson, Uniform and Exponential distributions; Poisson Process - basic concept and numerical simulation; Numerical method for stochastic simulation of biochemical network- Gillespie's algorithm. Stochasticity in gene expression and non-genetic heterogeneity.

Analysis of large networks: Basic concepts of Graph theory - degree distribution, clustering coefficient, pathlength, shortest path, Betweenness centrality; Random Networks - Erdös-Rényi Model. Properties of scale free networks; Barabási-Albert (BA) model; Network by duplication and divergence; Properties of large protein-protein interaction network, genetic network, and metabolic networks.

Text Books

1. Ingalls, Brian P. Mathematical Modeling in Systems Biology: An Introduction (1st edition). MIT Press, 2013.

2.Wilkinson, Darren J. Stochastic Modelling for Systems Biology. Chapman & Hall, 2006.

3. Junker, Bjorn H.; Schreiber, Falk (ed). Analysis of Biological Networks. John Wiley & Sons, 2008.

Reference books

1. Alon, Uri. An Introduction to Systems Biology-Design Principles of Biological Circuits. CRC Press, 2007.

2. Szallasi, Zoltan; Stelling, Jörg; Periwal, Vipul (ed). System Modeling in Cell Biology, From Concepts to Nuts and Bolts. The MIT Press, 2006.

Evaluation & Grading:

Evaluation will be based on quizzes, along with mid semester and end semester examinations. Grading from AS to DD and F, as per standard grading system followed by institute.

BT 420

Drug Design and Discovery

L T P C
3 0 0 6
Elective
Lectures: 40-42

Description/Preamble

The Drug Discover is one of the most crucial and vital components of contemporary Biosciences and Bioengineering. This current course is designed to introduce postgraduate students to various aspects of Drug Design and Discovery process. Further, steps required to take this drug for human use to the market, including the clinical trial and of regulatory clearances are also included. The course aims to provide good understanding of drug discovery in the pharmaceutical industry as well as insight in to how new drugs are discovered. The courses covers mostly experimental approaches with some exposure to computer aided drug discovery.

Industrial Relevance

Human health is a major global concern. The emerging and re-emerging diseases possess new challenge to this trillion dollar industry. The modern drug discovery utilizes multidisciplinary and the process demands very good knowledge about target validation to hit optimization and further clinical trials and regulatory approvals. The course provided good understanding of the entire process.

Objective

The objective of the course is to help the students understand the drug development process and use it for drug discovery research. The course focused on experimental approaches to drug discovery with some exposure to computational methods.

Pre-requisites

This course is designed as elective for M.Tech and PhD students of Department of Biosciences and Bioengineering.

Syllabus

Introduction to the drug discovery; Targets identification, Drug discovery : Drug scaffolds, Drugs derived from natural products, Existing drugs as a source for new drug discovery, Structure and ligand based drug design uing computational method; Lead optimization; Stereochemistry in drug design and concept of Pharmacophore; Enzymes as targets of drug design : Enzyme kinetics, inhibition, rational design of enzyme Inhibitors; Receptors as targets of drug design; In vitro ADME and In vivo Pharmacokinetics; Animal Models and Clinical trials; Intellectual property, Role of regulatory bodies. Case studies related to drug development (Anticancer, antiparasitic and antibiotics etc).

Text/ Reference Books

1. Textbook of Drug Design and Discovery, Povl Krogsgaard-Larsen, Tommy Liljefors and, 3rd Ed., Taylor & Francis 2005

2. Drugs: From Discovery to Approval. Rick Ng 3rd Ed., John Wiley and Sons 2015

3.Basic Principles of Drug Discovery and Development. Benjamin E Blass , 1st Ed., Academic Press 2015

4. Textbook of Drug Design and Discovery, Edited by Kristian Stromgaard, Povl Krogsgaard-Larsen, Ulf Madsen. 4th Ed., CRC Press 2015

Evaluation & Grading

Evaluation will be based on assignments, quizzes, final and mid semester examination. The assignment will be done as per the existing norms of the institute.

BT 421

Neurobiology

L T P C

3 0 0 6

Elective

Lectures: 40-42

Description/Preamble

This engineering science option course is designed to give students a comprehensive introduction to neurobiology. Topics like signaling and wiring of neural systems for vision, auditory, olfaction, motor systems are included with emphasis on basic concepts.

Industrial/Academic Relevance

Neurobiology has played an important role in understanding the biological substrates of language, memory, emotional processing, social conduct, personality, decision-making, planning and judgment. Neurobiology has a direct bearing on neurological diseases such as neurodegeneration, disorders of cognitive function, epilepsy and disorders of sensory information processing, and offer insights into potential therapies. World Health Organization predicts that neurological disorders might contribute 12% of total deaths globally by 2030. This discipline grows in importance to society as the aged proportion of population increases, bringing new challenges in the treatment and management of neurological disorders.

A basic understanding of the nervous system including its pathological conditions at undergraduate level is important. In today's world, molecular and cell biological techniques, biophysical recordings using a variety of electrophysiological and optical techniques, and computerized analysis are providing great insights into the functioning of single nerve cells, as well as complicated networks of neurons. This multidisciplinary approach is yielding insights into the rich complexity of mechanisms which influence how we think, feel, and act.

Given the good analytical and mathematical skills of undergraduates of Indian Institute of Technology, Guwahati, this complementary neurobiology training will equip them for employment in interdisciplinary areas of engineering and neuroscience, both within industry and academia.

Objective

The primary objective of this course is to provide a good understanding of complex neural circuits in human beings. The goal of this course is to train students across the entire spectrum of neurobiology. They should be able to move from one level to another in a critical and creative manner. Emphasis to develop an appreciation for translational research will also be stressed in this course.

Pre-requisite

This course is designed for undergraduates with no pre-requisites.

Syllabus

Introduction to Neurobiology; Signaling within Neurons; Signaling across synapses; Vision; Wiring of Visual system; Olfaction, taste, audition and somatosensation; Wiring of nervous system; Motor and Regulatory systems; Sexual behavior; Memory learning and synaptic plasticity; Brain disorders

Text Books

1. Liqun Luo, Principles of Neurobiology, Garland Science, 2015

References

1. Eric Kandel et al, Principles of Neural Science, McGraw Hill, 2013.

Evaluation & Grading

Evaluation will be based on assignments, lab exercises and small projects along with mid semester and end semester examinations. Grading from AS to DD and F, as per standard grading system followed by institute.